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EVOLUTION OF CEREMONIAL GOVERNMENT.

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I. INTRODUCTORY.

IF, excluding all purely private actions, we include under the name "conduct" all actions which involve direct relations with other persons; and if under the name "government" we include all control of such conduct, however arising; then we must say that the earliest kind of government, the most general kind of government, and the government which is ever spontaneously recommencing, is the government of ceremonial observance. More than this is true. Not simply does this kind of government precede other kinds, and not only has it in all places and times approached nearer to universality of influence, but it has ever had, and continues to have, the largest share in regulating men's lives.

Proof that the modifications of conduct called "manners" and "behavior" arise long before those which political and religious restraints cause, is yielded by the fact that, besides preceding social evolution, they precede human evolution: they are traceable among the higher animals. The dog afraid of being beaten, comes crawling up to his master, clearly manifesting the desire to submit. Nor is it solely to human beings that dogs use such propitiatory actions: they do the like one to another. All have occasionally seen how, on the approach of some formidable-looking Newfoundland or mastiff, a small spaniel, in the extremity of its terror, throws itself on its back with legs in the air. Instead of threatening resistance by growls and showing of teeth, as it might have done had not resistance been hopeless, it spontaneously assumes the attitude that would result from defeat in battle, tacitly saying, "I am conquered, and at your mercy." Clearly, then, besides certain modes of behavior expressing affection,

which are established still earlier in creatures lower than man, there are established certain modes of behavior expressing subjection.

After recognizing this fact, we shall be prepared to recognize the fact that daily intercourse among the lowest savages, whose small, loose groups, scarcely to be called social, are without political or religious regulation, is under a considerable amount of ceremonial regulation. No ruling agency, beyond that arising from personal superiority, characterizes the scattered hordes of Australians; but they have imperative ceremonies. Strangers meeting have to remain some time silent; a mile from an encampment approach must be heralded by loud "cooeys;" a green bough is used as an emblem of peace; and brotherly feeling is indicated by exchange of names. So the Tasmanians, similarly without government save that implied by predominance of a leader during war, had settled ways of indicating peace and defiance. The Esquimaux, too, though without social ranks or anything like chieftainship, have understood usages for the treatment of guests.

Kindred evidence may be joined with this. Ceremonial control is highly developed in many places where the other forms of control are but rudimentary. The wild Comanche "exacts the observance of his rules of etiquette from strangers," and "is greatly offended" by any breach of them. When Araucanians meet, the inquiries, felicitations, and condolences, which custom demands are so elaborate, that "the formality occupies ten or fifteen minutes." Of the ungoverned Bedouins we read that "their manners are sometimes dashed with a strange ceremoniousness;" and the salutations of Arabs are such that the "compliments in a well-bred man never last less than ten minutes." "We were particularly struck," says Livingstone, "with the punctiliousness of manners shown by the Balonda." "The Malagasy have many different forms of salutation, of which they make liberal use. . . . Hence in their general intercourse there is much that is stiff, formal, and precise." A Samoan orator, when speaking in parliament, "is not contented with a mere word of salutation, such as 'gentlemen,' but he must, with great minuteness, go over the names and titles, and a host of ancestral references, of which they are proud."

That ceremonial restraint, preceding other forms of restraint, continues ever to be the most widely-diffused form of restraint, we are shown by such facts as that in all intercourse between societies, civilized, semi-civilized, or barbarous, as well as in all intercourse between members of each society, the decisively governmental actions are usually prefaced by this government of observances. The embassy may fail, negotiation may be brought to a close by war, coercion of one society by another may set up wider political rule with its peremptory commands; but there is habitually this more general and vague regulation of conduct preceding the more special and definite.

So within a community, acts of relatively stringent control coming from ruling agencies, civil and religious, begin with and are qualified by this ceremonial control, which not only initiates but in a sense envelops all other. Functionaries, ecclesiastical and political, coercive as their proceedings may be, conform them in large measure to the requirements of courtesy. The priest, however arrogant, fulfills the usages of civility; and the officer of the law performs his duty subject to certain propitiatory words and movements.

Yet another indication of primordialism may be named. This species of control establishes itself anew with every fresh relation among individuals. Even between intimates those greetings which are requisite to signify continuance of respect, precede each renewal of intercourse. Though their particular form may be settled by custom, such greetings are in substance direct results of the desire not to offend. And in presence of a stranger, say in a railway-carriage, a certain self-restraint, joined with some such act as the offer of a newspaper, shows the spontaneous rise of a propitiatory behavior such as even the rudest of mankind are not without.

So that the modified forms of action produced in men by the presence of their fellows, and which are seen alike in the otherwise-uncontrolled members of the lowest social groups and in the otherwise-controlled members of the highest social groups, constitute that comparatively vague control out of which other more definite controls are evolved—the primitive undifferentiated kind of government from which the political and religious governments are differentiated, and within which they ever continue immersed.

This proposition looks strange mainly because, when studying less-advanced societies, we carry with us our developed conceptions of law and religion. Swayed by them, we fail to perceive that what we think the essential parts of sacred and secular regulations were originally subordinate parts, and that the essential parts consisted of ceremonial observances.

It is clear, *a priori*, that this must be so if social phenomena are evolved. A political organization or a settled cult cannot suddenly come into existence, but implies prëestablished subordination. Before there are laws, there must be submission to some potentate enacting and enforcing them. Before religious obligations are recognized, there must be acknowledged one or more supernatural powers. Evidently, then, the behavior expressing obedience to a ruler, visible or invisible, must precede in time the civil or religious restraints he imposes. And this inferable precedence of ceremonial government is a precedence we everywhere find.

How in the political sphere fulfillment of forms signifying subordination is the primary thing, early European history shows us. During times when the question, who should be master, was in course of

settlement, now in small areas and now in larger areas uniting them, there was scarcely any of the regulation which developed civil government brings; but there was insistance on allegiance humbly expressed. While each man was left to guard himself, and blood-feuds between families were unchecked by the central power—while the right of private vengeance was so well recognized that the Salic law made it penal to carry off enemies' heads from the stakes on which they were exhibited near the dwellings of those who had killed them; there was a rigorous demanding of oaths of fidelity to political superiors and periodic manifestations of loyalty. Simple homage, growing presently into liege homage, was paid by smaller rulers to greater; and the vassal who, kneeling ungirt and swordless before his suzerain, professed his subjection and then entered on possession of his lands, was little interfered with so long as he continued to display his vassalage in court and in camp. Refusal to go through the required observances was tantamount to rebellion; as at the present time in China, where disregard of the forms of behavior prescribed toward each grade of officers "is considered to be nearly equivalent to a rejection of their authority." Among peoples in lower stages this connection of social traits is still better shown. Referring to the extreme ceremoniousness of the Tahitians, Ellis writes: "This peculiarity appears to have accompanied them to the temples, to have distinguished the homage and the service they rendered to their gods, to have marked their affairs of state, and the carriage of the people toward their rulers, to have pervaded the whole of their social intercourse." Meanwhile, he says, they were destitute "of even oral laws and institutes:" so verifying the statement of Cook that there was no public administration of justice. Again, from Mariner we learn that if any one in Tonga were to neglect the proper salutation in presence of a superior noble, some calamity from the gods would be expected as a punishment for the omission; and his list of Tongan virtues commences with "paying respect to the gods, nobles, and aged persons." When to this we add his statement that many actions reprobated by the Tongans are not thought intrinsically wrong, but are wrong merely if done against gods or nobles, we get proof that, along with high development of ceremonial control, the sentiments, ideas, and usages, out of which civil government comes, were but feebly developed. Similarly in the ancient American states. The laws of the Mexican king, Montezuma I., mostly related to the intercourse of, and the distinctions between, classes. In Peru, "the most common punishment was death, for they said that a culprit was not punished for the delinquencies he had committed, but for having broken the commandment of the Ynca." There had not been reached the stage in which the transgressions of man against man are the wrongs to be redressed, and in which there is consequently a proportioning of penalties to injuries; but the real crime was insubordination: implying

that insistance on marks of subordination constituted the essential part of government. A statement of Thunberg shows us that in Japan, so elaborately ceremonious in its life, exactly the same theory led to exactly the same result. And here we are reminded that even in societies so advanced as our own there continue the traces of a kindred early condition. "Indictment for felony," says Wharton, "is" (for a transgression) "against the peace of our lord the king, his crown and dignity in general;" the injured individual being ignored. Evidently the implication is that obedience was the primary requirement, and behavior expressing it the first modification of conduct insisted on.

Religious control, still better, perhaps, than political control, shows us this general truth. When we find that rites performed at graves, becoming afterward religious rites performed at altars in temples, were at first acts done for the benefit of the ghost, either as originally conceived or as ideally expanded into a deity—when we find that the sacrifices and libations, the immolations and blood-offerings and mutilations, all begun to profit or to please the double of the dead man, were continued on larger scales where the double of the dead man was especially feared—when we find that fasting as a funeral rite gave origin to religious fasting, that praises of the deceased and prayers to him grew into religious praises and prayers—we are shown why primitive religion consisted almost wholly of propitiatory observances. Though in certain rude societies now existing, one of the propitiations is the repetition of injunctions given by the departed father or chief, joined in some cases with expressions of penitence for breach of them, and though we are shown by this that from the first there exists the germ out of which grow the sanctified precepts eventually constituting important adjuncts to religion; yet, since the supposed supernatural beings are at first regarded as retaining after death the desires and passions that distinguished them during life, this rudiment of a moral code is originally but an insignificant part of the cult: due rendering of those offerings, and praises, and marks of subordination, by which the good-will of the ghost or god is to be obtained, forming the chief part. Everywhere we meet with proofs. We read of the Tahitians that "religious rites were connected with almost every act of their lives;" and we read kindred statements respecting the uncivilized and semi-civilized in general. The Sandwich-Islanders, along with scarcely any of that ethical element which the conception of religion includes among ourselves, had a rigorous and elaborate ceremonial. Noting that *tabu* means literally "sacred to the gods," I quote the following account of its observance in Hawaii from Ellis:

"During the season of strict tabu, every fire or light in the island or district must be extinguished; no canoe must be launched on the water, no person must bathe; and except those whose attendance was required at the temple, no indi-

vidual must be seen out-of-doors; no dog must bark, no pig must grunt, no cock must crow. . . . On these occasions they tied up the mouths of the dogs and pigs, and put the fowls under a calabash, or fastened a piece of cloth over their eyes."

And how completely the idea of transgression was associated in the mind of the Sandwich-Islander with breach of ceremonial observance, is shown in the fact that "if any one made a noise on a tabu-day .... he must die." Through stages considerably advanced, religion continues to be thus constituted. When questioning the Nicaraguans concerning their creed, Oviedo, eliciting the fact that they confessed their sins to an appointed old man, asks what sort of sins they confessed; and the first clause of the answer is, "We tell him when we have broken our festivals and not kept them." Similarly of the Peruvians, we read that "the most notable sin was neglect in the service of the huacas" (spirits, etc.); and a large part of life was spent in propitiating the apotheosized dead. How elaborate the observances, how frequent the festivals, how lavish was the expenditure, by which, among the ancient Egyptians, the good-will of supernatural beings was sought, the records everywhere show us; and that with them religious duty consisted in thus ministering to the desires of ancestral ghosts, deified in various degrees, we are shown by the prayer of Rameses to his father Ammon, in which he claims his help in battle because of the many bulls he has sacrificed to him. With the Hebrews in pre-Mosaic times it was the same. As Kuenen remarks, the "great work and enduring merit" of Moses was that he gave dominance to the moral element in religion. In his reformed creed, "Jahveh is distinguished from the rest of the gods in this, that he will be served, not merely by sacrifices and feasts, but also, nay, in the first place, by the observance of the moral commandments." That the piety of the Greeks included diligent performance of rites at tombs, and that the Greek god was especially angered by non-observance of propitiatory ceremonies, are familiar facts; and credit with a god was claimed by the Trojan as by the Egyptian, not on account of rectitude, but on account of oblations made; as is shown by Chryses's prayer to Apollo. So, too, Christianity, originally a renewed development of the ethical element at the expense of the ceremonial element, losing as it spread those early traits which distinguished it from lower creeds, displayed, in mediæval Europe, a relatively large amount of ceremony and a relatively small amount of morality. Of the seventy-three chapters constituting the Rule of St. Benedict, nine concern the moral and general duties of the brothers, while thirteen concern the religious ordinances. And how the idea of criminality attached to disregard of ordinances is proved by the following passage from the Rule of St. Columbanus:

"A year's penance for him who loses a consecrated wafer; six months for him who suffers it to be eaten by mites; twenty days for him who lets it turn

red; forty days for him who contemptuously flings it into water; twenty days for him who brings it up through weakness of stomach; but, if through illness, ten days. He who neglects his Amen to the Benedicite, who speaks when eating, who forgets to make the sign of the cross on his spoon, or on a lantern lighted by a younger brother, is to receive six or twelve stripes."

That from the times when men condoned crimes by building chapels and going on pilgrimages, down to present times, when barons no longer invade one another's territories or torture Jews, there has been a decrease of ceremony along with an increase of morality, is clear; though if we look at unadvanced parts of Europe, such as Naples or Sicily, we see that even now observance of rites is in them a much larger component of religion than obedience to moral rules. And when we remember how modern is the rise of Protestantism, which, less elaborate and imperative in its forms, does not habitually compound for transgressions by performance of acts expressing subordination, and how very recent is the spread of dissenting Protestantism, in which this change is carried further; we are shown that the subordination of ceremony to morality characterizes religion only in its later stages.

Mark, then, what follows. If the two kinds of control which eventually grow into civil and religious governments, originally include scarcely anything beyond observance of ceremonies, the precedence of ceremonial control over other controls is a corollary.

Divergent products of evolution betray their kinship by severally retaining certain traits which belonged to that from which they were evolved; and the implication is, that whatever traits they have in common, arose earlier in time than did the traits which distinguish them from one another. If fish, reptiles, birds, and mammals, all possess vertebral columns, it follows, on the evolution hypothesis, that the vertebral column became a part of the organization at an earlier period than did the four-chambered heart, the teeth in sockets, and the mammæ, which distinguish one of these groups, or than did the toothless beak, the tri-locular heart, and the feathers, which distinguish another of these groups, and so on. Applying this principle in the present case, it is inferable that if the controls classed as civil, religious, and social, have certain common characters, these characters, older than are these now differentiated kinds of control, must have belonged to the primitive control out of which they developed. Ceremonial acts, then, have the highest antiquity; for these differentiated kinds of control all exhibit them.

There is the making of presents: this is one of the acts showing subordination to a ruler in early stages; it is a religious rite, performed originally at the grave and later on at the altar; and from the beginning it has been a means of showing consideration in social intercourse and securing good-will. There are the obeisances:

these, of their several kinds, serve to express reverence in its various degrees, to gods, to rulers, and to private persons; here the prostration is habitually seen, now in the temple, now before the monarch, and now to a powerful man; here there is genuflection in presence of idols, rulers, and fellow-subjects; here the salaam is more or less common to the three cases; here uncovering of the head is a sign alike of worship, of loyalty, and of respect; and here the bow serves the same three purposes. Similarly with titles: father is a name of honor applied to a god, to a king, and to an honored individual; so too is lord; and so are sundry other names. The same thing holds of humble speeches: professions of inferiority and subjection on the part of the speaker are used to secure divine favor, the favor of a ruler, and the favor of a private person. Once more, it is thus with words of praise; telling a deity of his greatness constitutes a large element of worship; despotic monarchs are addressed in terms of exaggerated eulogy; and where ceremony is dominant in social intercourse, extravagant compliments are addressed to private persons.

In many of the less-advanced societies, and also in the more advanced that have retained early types of organization, we find various other examples of observances expressing subordination, that are common to the three kinds of control—civil, religious, and social. Among the Malayo-Polynesians the offering of the first fish, and of first fruits, is used as a mark of respect alike to gods and to chiefs; and the Feejeeans make the same gifts to their gods as they do to their chiefs—food, turtles, whales' teeth. In Tonga, "if a great chief takes an oath, he swears by the god; if an inferior chief takes an oath, he swears by his superior relation, who, of course, is a greater chief." In Feejee, "all are careful not to tread on the threshold of a place set apart for the gods: persons of rank stride over; others pass over on their hands and knees. The same form is observed in crossing the threshold of a chief's house." In Siam, "at the full moon of the fifth month, the talapoins" (priests) "wash the idol with perfumed water. . . . The people also wash the sancrats and other talapoins; and then in the families children wash their parents." China affords good instances. "At his accession, the emperor kneels thrice and bows nine times before the altar of his father, and goes through the same ceremony before the throne on which is seated the empress dowager. On his then ascending his throne, the great officers, marshaled according to their ranks, kneel and bow nine times. And the equally ceremonious Japanese furnish kindred evidence. "From the emperor to the lowest subject in the realm there is a constant succession of prostrations. The former, in want of a human being superior to himself in rank, bows humbly to some pagan idol; and every one of his subjects, from prince to peasant, has some person before whom he is bound to cringe and crouch in the dirt:" that is, religious, political, and social subordination are expressed by the same form of behavior.

These indications of a general truth, which will be abundantly exemplified when treating of each kind of ceremonial observance, I here give in brief, as further showing that the control of ceremony precedes in order of evolution the civil and religious controls, and has therefore to be first dealt with.

On passing from the most general to the less general aspects of ceremonial government, we are met by the question, "How do there arise those modifications of behavior which constitute it?" Commonly it is assumed that they are consciously fixed upon as symbolizing reverence or respect. In pursuance of the usual method of speculating about primitive practices, developed ideas are read back into undeveloped minds. The supposition is of the same kind as that which gave origin to the social-contract theory: a kind of conception that has become familiar to the civilized man is supposed to have been familiar to man in his earliest state. But, just as little basis as there is for the belief that primitive men deliberately made social contracts, is there for the belief that primitive men deliberately adopted symbols. The current error is best seen on turning to the most developed kind of symbolization—that of language. The savage does not sit down and knowingly coin a word; but the words which he finds in use, and the new ones which come into use during his life, grow up unawares by *onomatopœa*, or by vocal suggestions of qualities, or by metaphor which some observable likeness suggests. Among civilized peoples, however, who have learned that words are symbolic, new words are frequently chosen to symbolize new ideas. So, too, is it with written language. The early Egyptian never thought of choosing a sign to represent a sound, but his records began, as those of North American Indians begin now, with rude pictures of the transactions to be kept in memory; and, as the process of recording extended, the pictures, abbreviated and generalized, lost more and more their likenesses to objects and acts, until, under stress of the need for expressing proper names, some of them were used phonetically, and signs of sounds came unawares into existence. But, in our days, there has been reached a stage at which, as short-hand shows us, special signs are consciously chosen to symbolize special sounds. The lesson taught is obvious. Just as it would be an error to conclude that, because we knowingly choose sounds to symbolize ideas, and marks to symbolize sounds, the like was originally done by savages and by barbarians; so is it an error to conclude that, because among the civilized, certain ceremonies (say those of freemasons) are arbitrarily fixed upon, so ceremonies were arbitrarily fixed upon by the uncivilized. Already, in indicating the primitiveness of ceremonial control, I have named some modes of behavior expressing subordination which have a natural genesis; and here the implication to which I would draw attention is that, until we have found a natural genesis for a ceremony, we may

be sure that we have not discovered its origin. The truth of this implication will seem less improbable on observing sundry ways in which spontaneous manifestations of emotion initiate formal observances.

The ewe bleating after her lamb that has strayed, and smelling now at at one and now at another of the lambs near her, but at length, by its odor, identifying as her own one that comes running up, doubtless, thereupon, experiences a wave of gratified maternal feeling; and, by repetition, there is established between this odor and this pleasure such an association that the first habitually produces the last; the smell becomes, on all occasions, agreeable by serving to bring into consciousness more or less of the philoprogenitive emotion. That, by some races of mankind, individuals are similarly identified, the Bible yields proof. Though Isaac, with senses dulled by age, fails thus to distinguish his sons from one another, yet the fact that, unable to see Jacob, and puzzled by the conflicting evidence his voice and his hands furnished, "he smelled the smell of his raiment, and blessed him," shows that different persons, even members of the same family, were perceived by the Hebrews to have their specific odors. And that perception of the odor possessed by one who is loved, yields pleasure, proof is given by another Asiatic race. Of a Mongol father, Timkowski writes: "He smelt from time to time the head of his youngest son, a mark of paternal tenderness usual among the Mongols, instead of embracing." Describing the Philippine-Islanders, Jagor says: "The sense of smell is developed among the Indians to so great a degree that they are able, by smelling at the pocket-handkerchiefs, to tell to which persons they belong ('Reisesk,' page 39); and lovers at parting exchange pieces of the linen they may be wearing, and during their separation inhale the odor of the beloved being, besides smothering the relics with kisses." So, too, is it with the Chittagong Hill people. Lewin tells us that "their manner of kissing is peculiar. Instead of pressing lip to lip, they place the mouth and nose upon the cheek and inhale the breath strongly. Their form of speech is not, 'Give me a kiss!' but 'Smell me!'" And now note a sequence. Inhalation of the odor given off by a loved person coming to be a mark of affection for him or for her, it happens that since men wish to be liked, and are pleased by display of liking, the performance of this act which signifies liking initiates a complimentary observance, and gives rise to certain modes of showing respect. The Samoans salute by "juxtaposition of noses, accompanied, not by a rub, but a hearty smell. They shake and smell the hands also, especially of a superior." And there are like salutes among the Esquimaux and the New-Zealanders.

The alliance between smell and taste being so close, we may naturally expect a class of acts which arise from tasting, parallel to the class of acts which smelling originates; and the expectation is fulfilled. That the billing of doves or pigeons and the like action of

love-birds indicate an affection which is gratified by the gustatory sensation, cannot well be questioned. No act of this kind on the part of an inferior creature, as of a cow licking her calf, can have any other origin than the direct prompting of a desire which gains by the act satisfaction; and in such a case the satisfaction is obviously that which vivid perception of offspring gives to the maternal yearning. In some animals like acts arise from other forms of affection. Licking the hand, or, where it is accessible, the face, is a common display of attachment on a dog's part; and when we remember how keen must be the olfactory sense by which a dog traces his master, we cannot doubt that to his gustatory sense, too, there is yielded some impression—an impression associated with those pleasures of affection which his master's presence gives. The inference that kissing as a mark of affection in the human race has a kindred origin, is sufficiently probable. Though kissing is not universal—though the negro races do not appear to understand it, and though, as we have seen, there are cases in which sniffing replaces it—yet, being common to unlike and widely-dispersed races, we may conclude that it originated in the same manner as the analogous action among lower creatures. Here, however, we are chiefly concerned to observe the indirect result. From kissing as a natural sign of affection, there is derived the kissing which, as a means of simulating affection, gratifies those who are kissed, and, by gratifying them, propitiates them. Hence an obvious root for the kissing of feet, hands, garments, as a part of ceremonial.

Feeling, sensational or emotional, causes muscular contractions, which are strong in proportion as it is intense; and, among other feelings, those of love and liking have an effect of this kind, which takes on its appropriate form. The most significant of the actions hence originating is not much displayed by inferior creatures, because their limbs are unfitted for prehension; but in the human race its natural genesis is sufficiently manifest. Mentioning a mother's embrace of her child will remind all that the strength of the embrace (unless restrained to prevent mischief) measures the strength of the feeling; and while reminded that the feeling thus naturally vents itself in muscular actions, they may further see that these actions are directed in such a way as to give satisfaction to the feeling by yielding a vivid consciousness of possession. That among adults the allied feelings originate like acts, scarcely needs adding. It is not so much these facts, however, as the derived facts, which we have to take note of. Here is another root for a ceremony: an embrace, too, serving to express liking, serves to propitiate in cases where it is not negatived by those other observances which subjection entails. We find it where governmental subordination is but little developed. Of some Snake Indians they met, we read in Lewis and Clarke, that "the three men immediately leaped from their horses, came up to Captain Lewis, and embraced him with great cordiality." Marcy tells of

a Comanche that, "seizing me in his brawny arms while we were yet in the saddle, and laying his greasy head upon my shoulder, he inflicted upon me a most bruin-like squeeze, which I endured with a degree of patient fortitude worthy of the occasion." So, too, Snow says the Fuegian "friendly mode of salutation was anything but agreeable. The men came and hugged me, very much like the grip of a bear."

Discharging itself in muscular actions which, in cases like the foregoing, are directed to an end, feeling in other cases discharges itself in undirected muscular actions. The resulting changes are habitually rhythmical. Each considerable movement of a limb brings it to a position at which a counter-movement is easy; both because the muscles producing the counter-movement are then in the best positions for contraction, and because they have had a brief rest. Hence the naturalness of striking the hands together or against other parts. We see this as a spontaneous manifestation of pleasure among children; and we find it giving origin to a ceremony among the uncivilized. Clapping of the hands is "the highest mark of respect" in Loango; and it occurs with kindred meaning among the Coast Negroes, the East Africans, the Dahomans. Joined with other acts expressing welcome, the people of Batoka "slap the outsides of their thighs;" the Balonda people, besides clapping their hands, sometimes "in saluting drum their ribs with their elbows;" while among the Coast Negroes and in Dahomey, snapping the fingers is one of the salutes. Rhythmical muscular motions of the arms and hands, thus expressing pleasure, real or pretended, in presence of another person, are not the only motions of this class: the legs come into play. Children often "jump for joy," and occasionally adults may be seen to do the like. Saltatory movements are therefore apt to grow into compliments. In Loango "many of the nobility salute the king by leaping with great strides backward and forward two or three times and swinging their arms." The Fuegians also, as the United States explorers tell us, show friendship "by jumping up and down."[1]

Feeling, discharging itself, contracts the muscles of the vocal organs, as well as other muscles; so that, along with bodily motions signifying pleasure, there go sounds, loud in proportion as the pleasure is great. Hence shouts, indicating joy in general, indicate the joy produced by meeting one who is beloved, and serve to give the appearance of joy before one whose good-will is sought. Among the

[1] In his "Early History of Mankind" (second edition, pp. 51, 52), Mr. Tylor thus comments on such observances: "The lowest class of salutations, which merely aim at giving pleasant bodily sensations, merge into the civilities which we see exchanged among the lower animals. Such are patting, stroking, kissing, pressing noses, blowing, sniffing, and so forth. . . . Natural expressions of joy, such as clapping hands in Africa, and jumping up and down in Tierra del Fuego, are made to do duty as signs of friendship or greeting." Mr. Tylor does not, however, indicate the physio-psychological sources of these actions.

Feejeeans, respect is "indicated by the *tama*, which is a shout of reverence uttered by inferiors when approaching a chief or chief town." In Australia, as we have seen, it is necessary on coming within a mile of an encampment to make loud *cooeys*—an action which, while primarily indicating pleasure at the coming reunion, further indicates those friendly intentions which a secret approach would render more than doubtful.

One more example may be named: Tears result from strong feeling—mostly from painful feeling, but also from pleasurable feeling when extreme. Hence, as a sign of joy, weeping occasionally passes into a complimentary observance. The beginning of such an observance is shown us by Hebrew traditions in the reception of Tobias by Raguel, when he finds him to be his cousin's son: "Then Raguel leaped up and kissed him and wept." And among some races there grows from this root a social rite. In New Zealand a meeting "led to a warm *tangi* between the two parties; but, after sitting opposite to each other for a quarter of an hour or more, crying bitterly, with a most piteous moaning and lamentation, the *tangi* was transformed into a *hungi*, and the two old ladies commenced pressing noses, giving occasional satisfactory grunts." And then we find it becoming a public ceremony on the arrival of a great chief: "The women stood upon a hill, and loud and long was the *tangi* to welcome his approach. Occasionally, however, they would leave off, to have a chat or a laugh, and then mechanically resume their weeping." Other Malayo-Polynesians do the like.

To these illustrations of the way in which natural manifestations of emotion originate ceremonies, may be added a few illustrations of the way in which ceremonies, not originating directly from spontaneous actions, nevertheless originate by natural sequence—not by intentional symbolization. Brief indications must suffice.

Livingstone tells us that blood-relations are formed in Central South Africa by imbibing a little of each other's blood. A like way of establishing brotherhood is used in Madagascar, in Borneo, and in many places throughout the world, and it was used among our remote ancestors. This is assumed to be a symbolic observance. On studying early ideas, however, and finding, as we have done, that the primitive man regards the nature of anything as inhering in all its parts, and therefore thinks he gets the courage of a brave enemy by eating his heart, or is inspired with the virtues of a deceased relative by grinding his bones and drinking them in water, we see that, by absorbing each other's blood, men are supposed to establish actual community of nature, and are also supposed to gain power over each other by possessing parts of each other.

Similarly with the ceremony of exchanging names. "To bestow his name upon a friend is the highest compliment that one man can offer another," among the Shoshones. The Australians exchange

names with Europeans, as a proof of brotherly feeling. This, which is a widely-diffused practice, arises from the belief that the name is a part of the individual. Possessing a man's name is equivalent to possessing something that forms a portion of his being, and enables the possessor to work mischief to him; and hence, among numerous peoples, a reason for studiously concealing names. To exchange names, therefore, is to establish some participation in one another's being, and at the same time to trust each with power over the other, implying great mutual confidence.

It is a usage among the people of Vate, "when they wish to make peace, to kill one or more of their own people, and send the body to those with whom they have been fighting to eat;" and, in Samoa, "it is the custom, on the submission of one party to another, to bow down before their conquerors, each with a piece of fire-wood and a bundle of leaves, such as are used in dressing a pig for the oven" (bamboo-knives being sometimes added), "as much as to say, 'Kill us and cook us, if you please.'" These facts I name because they clearly show a point of departure from which there might arise an apparently artificial ceremony. Let the traditions of cannibalism among the Samoans disappear, and this surviving custom of presenting fire-wood, leaves, and knives, as a sign of submission, would, in pursuance of the ordinary method of interpretation, be taken for an observance deliberately devised.

That peace should be signified among the Dakotas by burying the tomahawk, and among the Brazilians by a present of bows and arrows, may be cited as instances of what is in a sense symbolization, but what is in origin a modification of the action symbolized; for cessation of fighting is necessitated by putting away weapons, or by giving weapons to an antagonist. If, as among the civilized, a conquered antagonist delivers up his sword, the act of so making himself defenseless is an act of personal submission; but eventually it comes to be, on the part of a general, a sign that his army surrenders. Similarly, when, as in parts of Africa, "some of the free blacks become slaves voluntarily by going through the simple but significant ceremony of breaking a spear in the presence of their future master," we may properly say that the relation thus artificially established is as near an approach as may be to the relation established when an enemy, whose weapon is broken, is made a slave by his captor: the symbolic transaction simulates the actual transaction.

An instructive example comes next. I refer to the bearing of green boughs as a sign of peace, as an act of propitiation, and as a religious ceremony. As indicating peace the custom occurs among the Araucanians, Australians, Tasmanians, New Guinea people, New Caledonians, Sandwich-Islanders, Tahitians, Samoans, New-Zealanders; and branches were used by the Hebrews also for propitiatory approach (2 Maccabees xiv. 4). In some cases we find it employed to

signify not peace only but submission. Speaking of the Peruvians, Cieza says, "The men and boys came out with green boughs and palm-leaves to seek for mercy;" and among the Greeks, too, a suppliant carried an olive-branch. Wall-paintings left by the ancient Egyptians show us palm-branches carried in funeral processions to propitiate the dead; and, at the present time, "a wreath of palm-branches stuck in the grave" is common in a Moslem cemetery in Egypt. A statement of Wallis respecting the Tahitians shows it passing into a religious observance: a pendant left flying on the beach the natives regarded with fear, bringing green boughs and hogs, which they laid down at the foot of the staff. And that a portion of a tree was anciently an appliance of worship in the East is shown by the direction in Leviticus xxiii. 40, to take the "boughs of goodly trees, branches of palm-trees," etc., and "rejoice before the Lord:" a verification being furnished by the description of the chosen in heaven, who stand before the throne with "palms in their hands" (Revelation vii. 9). The explanation, when we get the clew, is simple. Many travelers' narratives illustrate the fact that laying down weapons on approaching strangers is taken to imply pacific intentions: the obvious reason being that opposite intentions are thus negatived. Of the Kaffirs, for instance, Barrow says, "'A messenger of peace' is known by this people from his laying down his *hassagai* or spear on the ground, at the distance of two hundred paces from those to whom he is sent, and by advancing thence with extended arms:" the extension of the arms evidently having the purpose of showing that he has no weapon secreted. But how is the absence of weapons to be shown when so far off that weapons, if carried, are invisible? Simply by carrying other things which are visible; and boughs covered with leaves are the most convenient and generally available things for this purpose. A verification is at hand. The Tasmanians had a way of deceiving those who inferred from the green boughs they were bringing in their hands that they were weaponless. They practised the art of holding their spears between their toes as they walked: "The black . . . . approaching him in pretended amity, trailed between his toes the fatal spear." Arbitrary, then, as this usage seems when observed in its later forms only, it proves to be by no means arbitrary when traced back to its origin. Taken as evidence that the advancing stranger is without arms, the green bough is primarily a sign that he is not an enemy. It is thereafter joined with other marks of friendship. It survives when the propitiation passes into submission. And so it becomes incorporated with various other actions which express reverence and worship.

One more instance I must add, because it conspicuously shows us how there grow up the interpretations of ceremonies as artificially-devised actions, when their natural origins are unknown. Describing Arab marriages, Baker says: "There is much feasting, and the unfor-

tunate bridegroom undergoes the ordeal of whipping by the relations of his bride, in order to test his courage. . . . If the happy husband wishes to be considered a man worth having, he must receive the chastisement with an expression of enjoyment, in which case the crowds of women in admiration again raise their thrilling cry." Here, instead of the primitive abduction violently resisted by the woman and her relatives—instead of the actual capture required to be achieved, as among the Kamtchadales, spite of the blows and wounds inflicted by "all the women in the village"—instead of those modifications of the "form of capture" in which, along with mock pursuit, there goes receipt by the abductor of more or less violence from the pursuers; we have a modification in which the pursuit has disappeared, and the violence is passively received. And then there arises the belief that this castigation of the bridegroom is a deliberately chosen way "to test his courage."

These facts are not given as adequately proving that, in all cases, ceremonies are modifications of actions which had at first direct adaptations to desired ends, and that their apparently symbolic characters result from their survival under changed circumstances. Here I have aimed only to indicate, in the briefest way, the reasons for rejecting the current hypothesis that ceremonies originate in conscious symbolization, and for justifying the belief that we may in every case expect to find them originating by evolution. This expectation we shall hereafter find abundantly fulfilled.

A chief reason why little attention has been paid to phenomena of this class, all-pervading and conspicuous as they are, is that while to most social functions there correspond structures too large to be overlooked, functions which make up ceremonial control have correlative structures so small as to seem of no significance. That ceremonial government has its special organization, just as the political and ecclesiastical governments have, is a fact habitually passed over, because, while the last two organizations have developed, the first has dwindled—in those societies, at least, which have reached the stage at which social phenomena become subjects of speculation. Originally, however, the officials who direct the rites expressing political subordination have an importance second only to that of the officials who direct religious rites; and the two officialisms are homologous. To whichever class belonging, these functionaries conduct propitiatory acts: the visible ruler being the propitiated person in the one case, and the ruler no longer visible being the propitiated person in the other case. Both are performers and regulators of worship—worship of the living king and worship of the dead king. In our advanced stage the differentiation of the divine from the human has become so great that this proposition looks scarcely credible. But on going back through stages in which the attributes of the conceived deity

are less and less unlike those of the visible man, and eventually reaching the early stage in which the other-self of the dead man, considered indiscriminately as ghost and god, is not to be distinguished, when he appears, from the living man; we cannot fail to see the alliance in Nature between the functions of those who minister to the ruler who has gone away and those who minister to the ruler who has taken his place. What remaining strangeness there may seem in this assertion of homology disappears, on remembering that in sundry ancient societies living kings were literally worshiped as dead kings were, and that the adoration of the living king by priests was but a more extreme form of the adoration habitually paid by all who served him.

Social organizations that are but little differentiated clearly show us several aspects of this kinship. In common with those below him, the savage chief proclaims his own great deeds and the achievements of his ancestors; and that in some cases this habit of self-praise long persists, Egyptian and Assyrian inscriptions prove. Advance from the stage at which the head-man lauds himself to the stage at which laudation of him is done by deputy is well typified in the contrast between the recent usage in Madagascar, where the king in public assembly was in the habit of relating "his origin, his descent from the line of former sovereigns, and his incontestable right to the kingdom," and the usage that existed in past times among ourselves, when the like distinctions and powers and claims of the king were publicly asserted for him by an appointed officer. As the ruler, extending his dominions and growing in power, gathers round him an increasing number of agents, the utterance of propitiatory praises, at first by all of these, becomes eventually distinctive of certain among them: there arise official glorifiers. "In Samoa, a chief in traveling is attended by his principal orator." In Feejee each tribe has its "orator, to make orations on occasions of ceremony." Dupuis tells us that the attendants of the chiefs of Ashantee eagerly vociferate the "strong names" of their masters; and a more recent writer describes certain of the king's attendants, whose duty it is to "give him names"—cry out his titles and high qualities. In kindred fashion a Yoruba king, when he goes abroad, is accompanied by his wives, who sing his praise. Now, when we meet with facts of this kind—when we read that in Madagascar "the sovereign has a large band of female singers, who attend in the court-yard, and who accompany their monarch whenever he takes an excursion, either for a short airing or distant journey;" when we are told that in China "his imperial majesty was preceded by persons loudly proclaiming his virtues and his power;" when we learn that among the ancient Chibchas the *hogotá* was received with "songs in which they sung his deeds and victories"—we cannot deny that these assertors of greatness and singers of praises do for the living king exactly that which priests and priest-

esses do for the dead king, and for the god who evolves from the dead king.

In societies that have their ceremonial governments largely developed, the homology is further shown. As such societies ordinarily have many gods of various powers, severally served by their official glorifiers, so they have various grades of living potentates, severally served by men who assert their greatness and demand respect. In Samoa, "a herald runs a few paces before, calling out, as he meets any one, the name of the chief who is coming." With a Madagascar chief in his palanquin, "one or two men with *assagais*, or spears, in their hands, ran along in front shouting out the name of the chief." In advance of an embassador in Japan there "first walked four men with brooms, such as always precede the retinue of a great lord, in order to admonish the people with cries of 'Stay, stay!' which means, 'Sit, or bow you down;'" and in China a magistrate making a progress is preceded by men bearing "red boards having the rank of the officer painted on them, running and shouting to the street-passengers: 'Retire, retire! keep silence, and clear the way!' Gong-strikers follow, denoting at certain intervals by so many strokes their master's grade and office."

Another parallelism exists between the official who proclaims the king's will and the official who proclaims the will of the deity—between the interpreter who conveys statements to the king and brings back his reply, and the priest who conveys the petitions or questions of worshipers, and explains the oracular response. In many places where regal power is extreme, the monarch is either invisible or cannot be directly communicated with: the living ruler thus simulating the dead and divine ruler, and requiring kindred intermediators. It was thus in ancient Mexico. Of Montezuma II. it is said that "no commoner was to look him in the face, and if one did, he died for it;" and further, that he did not communicate with any one "except by an interpreter." In Nicaragua the caziques "carried their exclusion so far as to receive messages from other chiefs only through officers delegated for that purpose." So of Peru, where some of the rulers "had the custom not to be seen by their subjects but on rare occasions," we read that at the first interview with the Spaniards, "Atahuallpa gave no answer, nor did he even raise his eyes to look at the captain (Hernando de Soto). But a chief replied to what the captain had said." With the Chibchas "the first of the court officers was the crier, as they said that he was the medium by which the will of the prince was explained." Throughout Africa at the present time like customs have generated like appliances. Speke tells us that, "in conversation with the King of Uganda, the words must always be transmitted through one or more of his officers." Among the inland negroes "it is quite beneath the dignity of an *attàh* to reply from the throne except through his 'mouth,' or prime-minister." In Da-

homey, "the sovereign's words are spoken to the *meu*, who informs the interpreter, who passes it on to the visitor, and the answer must trickle back through the same channels." And, concerning Abyssinia, where even the chiefs sit in their houses in darkness, so "that vulgar eyes may not gaze too plainly upon" them, we are told the king was "not seen when sitting in council," but "sat in a darkened room," and "observed through a window what was going on in the chamber without;" and also that he had "an interpreter, who was the medium of communication between the king and his people on state occasions; his name meant the voice or word of the king." I may add that this parallelism between the secular and sacred agents of communication is in some cases recognized by peoples whose institutions display it. Thomson tells us that the New Zealand priests were regarded as the embassadors of the gods.

There is a further evidence of this homology. Where, along with social development considerably advanced, ancestor-worship has remained dominant, and where gods and men are, consequently, but little differentiated, the two organizations are but little differentiated. China furnishes a good instance. Huc tells us that "the Chinese emperors are in the habit of deifying .... civil or military officers, whose life has been characterized by some memorable act, and the worship rendered to these constitutes the official religion of the mandarins." Further, we read in Gutzlaff that the emperor "confers various titles on officers who have left the world, and shown themselves worthy of the high trust reposed in them, creating them governors, presidents, overseers, etc., in Hades, and thus establishing his government even among the manes." And then we learn from Williams that the Li pu, or Board of Rites, examines and directs concerning the performances of the five kinds of ritual observances—those of a propitious and those of a felicitous nature, military and hospitable rites, and those of an infelicitous nature. Among its departments is that of ceremonial forms—the etiquette to be observed at court, the regulations of dresses, of carriages and riding-accoutrements, of followers and insignia, personal and written intercourse between the various ranks of peers. Another department superintends the rites to be observed in worshiping deities and spirits of departed monarchs, sages and worthies, etc.—statements showing that the same board regulates both religious ceremonial and civil ceremonial. To which summarized account I may add this quotation: "In court, the master of ceremonies stands in a conspicuous place, and with a loud voice commands the courtiers to rise and kneel, stand or march"—that is, he directs the worshipers of the monarch as a chief priest directs the worshipers of the god. Equally marked were, until lately, the kindred relations in Japan. With the sacredness of the mikado, and with his divine inaccessibility, travelers have familiarized us; but the implied confusion between the divine and the human went to a much greater

extent—an extent which would be scarcely credible, did not independent witnesses testify to it. Dickson says:

"The Japanese generally are imbued with the idea that their land is a real 'shin koku, a kami no kooni'—that is, the land of spiritual beings or kingdom of spirits. They are led to think that the emperor rules over all, and that, among other subordinate powers, he rules over the spirits of the country. He rules over men, and is to them the fountain of honor; and this is not confined to honors in this world, but is extended to the other, where they are advanced from rank to rank by the orders of the emperor."

Similarly we are told by Mitford that—

"In the days of Shogun's power the mikado remained the Fountain of Honor, and, as chief of the national religion and the direct descendant of the gods, dispensed divine honors. So recently as last year [1870] a decree of the Mikado appeared in the Government *Gazette*, conferring posthumous divine honors upon an ancestor of the Prince of Coshiu."

And then we read that under the Japanese cabinet, one of the eight administrative boards, the Ti bu shio, "deals with the forms of society, manners, etiquette, worship, ceremonies for the living and the dead," etc.: the propitiation of living persons and the propitiation of dead persons and deities have a supreme regulative centre in common.

Western peoples, among whom during the Christian era differentiation of the divine from the human has become very decided, show us in a less marked manner the homology between the ceremonial organization and the ecclesiastical organization. Still it is, or rather, was once, clearly traceable. In feudal days, beyond the lord-high chamberlains, grand-masters of ceremonies, ushers, and so forth, belonging to royal courts, and the kindred officers found in the households of subordinate rulers and nobles—officers who conducted propitiatory observances—there were the heralds. These formed a class of ceremonial functionaries, in various ways resembling a priesthood. Just noting as significant the remark of Scott that, "so intimate was the union betwixt chivalry and religion esteemed to be, that the several gradations of the former were seriously considered as parallel to those of the Church," I go on to point out that these officers, pertaining to the institutions of chivalry, formed a body which, where it was highly organized, as in France, had five ranks: *chevaucheur*, *poursuivant d'armes*, *heraut d'armes*, *roi d'armes*, and *roi d'armes de France*. Into these ranks its members were successively initiated by a species of baptism—wine being substituted for water. They held periodic chapters in the church of Saint-Antoine. When bearing mandates and messages they were similarly dressed with their masters, royal or noble, and were similarly honored by those to whom they were sent, having thus a deputed dignity akin to the deputed sacredness of priests. By the chief king-at-arms and five others, local visitations were made for inquiry and discipline, as ecclesiastical visita-

tions were made; and in various other ways the functions of the organization were allied to priestly functions. Heralds verified the titles of those who aspired to the distinctions of chivalry, as priests decided on the fitness of applicants for the sanctions of the Church; and on the occasions of their visitations they were to "correct things ill and dishonest," and to advise princes—duties allied to those of priests. Besides announcing the wills of earthly rulers, as priests of all religions announce the wills of heavenly rulers, they were glorifiers of the first, as priests were of the last—part of their duty to those they served being "to publish their praises in foreign lands." At the burials of kings and princes, where observances for honoring the living and observances for honoring the dead came in contact, the kinship of a herald's function to the function of a priest was again shown; for, besides putting in the tomb the insignia of rank of the deceased potentate, and in that manner sacrificing to him, the herald had to write, or to get written, a eulogy—had to initiate that worship of the dead out of which grow higher forms of worship. Similar, if less elaborate, was the system in England. Heralds wore crowns, had royal dresses, and used the plural "we." Anciently, there were two heraldic provinces, with their respective chief heralds, like two dioceses. Further development produced a garter king-at-arms, with provincial kings-at-arms presiding over minor heraldic officers; and, in 1483, all were incorporated into the College of Heralds. As in France, visitations were made for the purpose of verifying existing titles and honors, and authorizing others; and funeral rites were so far under heraldic control that, among the nobility, no one could be buried without the assent of the herald.

Why these structures which discharged ceremonial functions once conspicuous and important dwindled, while civil and ecclesiastical structures developed, it is easy to see. Propitiation of the living has been, from the outset, necessarily more localized than propitiation of the dead. The existing ruler can be worshiped only in his presence, or, at any rate, within his dwelling or in its neighborhood. Though in Peru adoration was paid to images of the living Yncas; and though in Madagascar King Radama, when absent, had his praises sung in the words, "God is gone to the west, Radama is a mighty bull;" yet, generally, the obeisances and laudations expressing subordination to the great man while alive, are not made when they cannot be witnessed by him or his immediate dependents. But when the great man dies and there begin the awe and fear of his ghost, conceived as able to reappear anywhere, propitiations are no longer so narrowly localized; and in proportion as, with formation of larger societies, there comes development of deities greater in supposed power and range, dread of them and reverence for them are felt simultaneously over wide areas. Hence the official propitiators, multiplying and spreading, severally carry on their worships in many places at the

same time—there arise large bodies of ecclesiastical officials. Not for these reasons alone, however, does the ceremonial organization fail to grow as the other organizations do: their development causes its decay. Though, during early stages of social integration, local rulers have their local courts with appropriate officers of ceremony, the process of consolidation and increasing subordination to a central government, results in decreasing dignity of the local rulers, and disappearance of the official upholders of their dignities. Among ourselves in past times, "dukes, marquises, and earls, were allowed a herald and pursuivant; viscounts, and barons, and others not ennobled, even knights bannerets, might retain one of the latter;" but, as the regal power grew, "the practice gradually ceased; there were none so late as Elizabeth's reign." Yet further, the structure carrying on ceremonial control slowly falls away, because its functions are gradually encroached upon. Political and ecclesiastical regulations, though at first insisting mainly on conduct expressing obedience to rulers, divine and human, develop more and more in the directions of equitable restraints on conduct between individuals, and ethical precepts for the guidance of such conduct; and in doing this they trench more and more on the sphere of the ceremonial organization. In France, besides having the semi-priestly functions we have noted, the heralds were "judges of the crimes committed by the nobility;" and they were empowered to degrade a transgressing noble, confiscate his goods, raze his dwellings, lay waste his lands, and strip him of his arms. In England, too, certain civil duties were discharged by these officers of ceremony. Till 1688, the provincial kings-at-arms had "visited their divisions, receiving commissions for that purpose from the sovereign, by which means the funeral certificates, the descents, and alliances of the nobility and gentry, had been properly registered in this college" (of heralds). "These became records in all the courts at law." Evidently the assumption of functions of these kinds by ecclesiastical and political agents has joined in reducing the ceremonial structures to those rudiments which now remain, in the almost-forgotten Heralds' College, and in the court officials who regulate intercourse with the sovereign.

Before passing to a detailed account of ceremonial government under its various aspects, it will be well to sum up the results of this preliminary survey. They are these:

That control of conduct which we distinguish as ceremony precedes the civil and ecclesiastical controls. It begins with sub-human types of creatures; it occurs among otherwise ungoverned savages; it often becomes highly developed where the other kinds of rule are little developed; it is ever being spontaneously generated afresh between individuals in all societies; and it envelops the more definite restraints which state and church exercise. The primitiveness of ceremonial government is further shown by the fact that, at first,

political and religious governments do little more than maintain systems of ceremony, directed toward particular persons living and dead: the codes of law enforced by the one, and the moral codes enunciated by the other, come later. There is, again, the evidence derived from the possession of certain elements in common by the three controls, social, political, and religious; for the forms observable in social intercourse occur also in the political and religious intercourse as forms of homage and forms of worship. More significant still is the circumstance that ceremonies may mostly be traced back to certain spontaneous acts which manifestly precede legislation, civil and ecclesiastical. Instead of arising by dictation or by agreement, which would imply the preëstablished organization required for making and enforcing rules, they arise by modifications of acts performed for personal ends; and so prove themselves to grow out of individual conduct before social arrangements exist to control it. Lastly, we note that when there arises a political head, who, demanding subordination, is at first his own master of the ceremonies, and who presently collects round him subservient attendants performing propitiatory acts, which by repetition are made definite and fixed, there arise ceremonial officials. Though, along with the growth of organizations which enforce civil laws and enunciate moral precepts, there has been such a decay of the ceremonial organization as to render it among ourselves inconspicuous; yet in early stages the body of officials who conduct propitiation of living rulers, supreme and subordinate, homologous with the body of officials who conduct propitiation of dead apotheosized rulers, major and minor, is a considerable element of the social structure; and it dwindles only as fast as the structures, political and ecclesiastical, which exercise controls more definite and detailed, usurp its functions.

Carrying with us these general conceptions, let us now pass to the several components of ceremonial rule. We will deal with them under the heads—Trophies, Mutilations, Presents, Obeisances, Forms of Address, Titles, Badges and Costumes, Further Class Distinctions, Fashion, Past and Future of Ceremony.

GEYSERS AND HOW THEY ARE EXPLAINED.[1]

By Prof. JOSEPH LE CONTE.

A GEYSER may be defined as a *periodically eruptive spring.* They are found only in Iceland, in the Yellowstone Park, United States, and in New Zealand. The so-called geysers of California are rather fumaroles. Those of Iceland have been long studied; we will, therefore, describe these first.

[1] From Le Conte's "Elements of Geology."

Iceland is an elevated plateau about two thousand feet high, with a narrow marginal habitable region sloping gently to the sea. The elevated plateau is the seat of every species of volcanic action, viz., lava-eruptions, solfataras, mud-volcanoes, hot springs, and geysers.

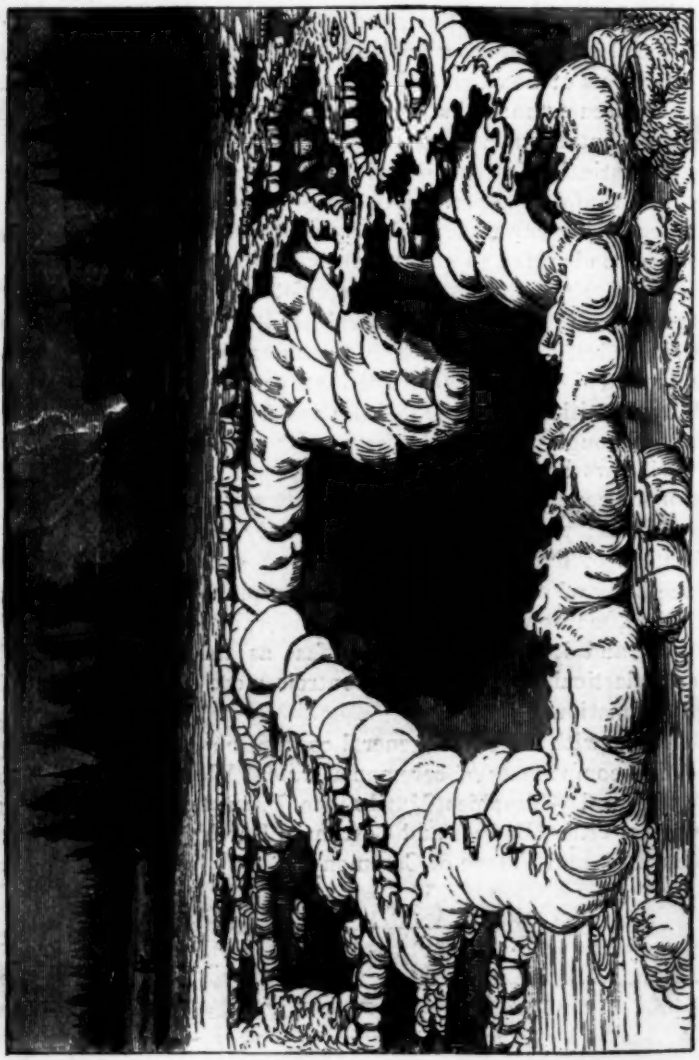


FIG. 1.—GEYSER NEAR THE GIANT, SHOWING THE ORNAMENTAL CHARACTER OF THE BORDER (after Hayden).

These last exist in great numbers; more than one hundred are found in a circle of two miles diameter. One of these, the Great Geyser, has long attracted attention.

The Great Geyser is a basin or pool fifty-six feet in diameter, on the top of a mound thirty feet high. From the bottom of the basin

descends a funnel-shaped pipe eighteen feet in diameter at top, and seventy-eight feet deep. Both the basin and the tube are lined with silica, evidently deposited from the water. The natural inference is, that the mound is built up by deposit from the water, in somewhat the same manner as a volcanic cone is built up by its own ejections. In the intervals between the eruptions the basin is filled to the brim with perfectly transparent water, having a temperature of about 170° to 180°.

1. Immediately preceding the eruption sounds like cannonading are heard beneath, and bubbles rise and break on the surface of the water. 2. A bulging of the surface is then seen, and the water overflows the basin. 3. Immediately thereafter the whole of the water in the tube and basin is shot upward one hundred feet high, forming a fountain of dazzling splendor. 4. The eruption of water is immediately followed by the escape of steam with a roaring noise. These last two phenomena are repeated several times, so that the fountain continues to play for several minutes, until the water is sufficiently cooled, and then all is again quiet until another eruption. The eruptions occur tolerably regularly every ninety minutes, and last six or seven minutes. Throwing large stones into the tube has the effect of bringing on the eruption more quickly.

In magnificence of geyser displays, however, Iceland is far surpassed by the Yellowstone geysers in the basin of Firehole River. This wonderful geyser region is situated in the northwest corner of Wyoming, on an elevated volcanic plateau near the head-waters of the Madison River, a tributary of the Missouri, and of the Snake River, a tributary of the Columbia. The basin is only about three miles wide. About it are abundant evidences of prodigious volcanic activity in former times, and, although primary volcanic activity has ceased, secondary volcanic phenomena are developed on a stupendous scale and of every kind, viz.: hot springs, carbonated springs, fumaroles, mud-volcanoes, and geysers. In this vicinity there are more than 10,000 vents of all kinds. In some places, as on Gardiner's River, the hot springs are mostly lime-depositing; in others, as on Firehole River, they are geysers depositing silica.

FIG. 2.—CHIMNEY-LIKE VENTS (after Hayden).

In the upper geyser basin the valley is covered with a snowy de-

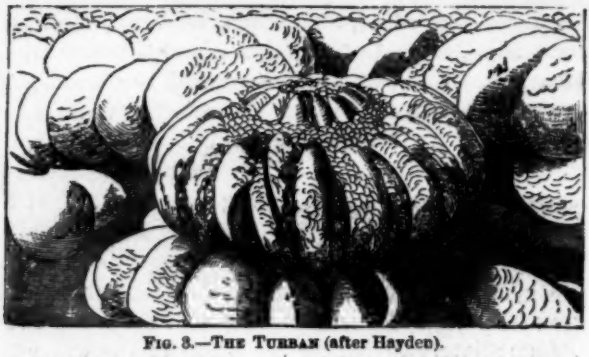


FIG. 3.—THE TURBAN (after Hayden).

FIG. 4.—GIANT GEYSER (after Hayden).

posit from the hot geyser-waters. The surface of the mound-like, chimney-like, and hive-like elevations, immediately surrounding the vents, is, in some cases, ornamented in the most exquisite manner by deposits of the same, in the form of scalloped embroidery set with pearly tubercles; in others, the siliceous deposits take the most fan-

FIG. 5.—BEEHIVE GEYSER (from a Drawing by Holmes).

tastic forms (Figs. 1, 2, 3). In some places the silica is deposited in large quantities, three or four inches deep, in a gelatinous condition like starch-paste. Trunks and branches of trees immersed in these waters are speedily petrified.

We can only mention a few of the grandest of these geysers:

1. The "Grand Geyser," according to Hayden, throws up a col-

umn of water six feet in diameter to the height of 200 feet, while the steam ascends 1,000 feet or more. The eruption is repeated every thirty-two hours, and lasts twenty minutes. In a state of quiescence the temperature of the water at the surface is about 150°.

2. The "Giantess" throws up a large column twenty feet in diameter to a height of sixty feet, and through this great mass it shoots up five or six lesser jets to a height of 250 feet. It erupts about once in every eleven hours, and plays twenty minutes.

3. The "Giant" (Fig. 4) throws a column five feet in diameter 140 feet high, and plays continuously for three hours.

4. The "Beehive" (Fig. 5), so called from the shape of its mound, shoots up a splendid column two or three feet in diameter to the height by measurement of 219 feet, and plays fifteen minutes.

5. "Old Faithful," so called from the frequency and regularity of its eruptions, throws up a column six feet in diameter to the height of 100 to 150 feet regularly every hour, and plays each time fifteen minutes.

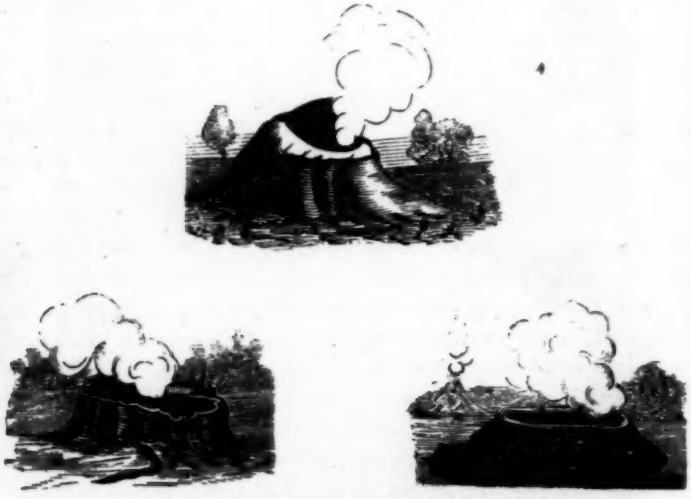


FIG. 6.—FORMS OF GEYSER-CRATERS (after Hayden).

The water of geysers is not volcanic water, but simple spring-water. A geyser is not, therefore, a volcano ejecting water, but a true spring. There has been much speculation concerning the cause of their truly wonderful eruptions.

According to Mackenzie, the eruptions of the Great Geyser may be accounted for by supposing its pipe connected by a narrow conduit with the lower part of a subterranean cave, whose walls are heated by the near vicinity of volcanic fires. Fig. 7 represents a section through the basin, tube, and supposed cave. Now, if meteoric water should run into the cave through fissures more rapidly than it can

evaporate, it would accumulate until it rose above, and therefore closed, the opening at *a*. The steam, now having no outlet, would condense in the chamber *b* until its pressure raised the water into the pipe, and caused it to overflow the basin. The pressure still continuing, all the water would be driven out of the cave, and partly up the pipe. Now, the pressure which sustained the whole column *a d* would not only sustain, but eject with violence, the column *c d*. The steam would escape, the ejected water would cool, and a period of quiescence would follow. If there were but one geyser in Iceland, this would be rightly considered a very ingenious and probable hypothesis, for without doubt we may conceive of a cave and conduit so constructed as to account for the phenomena. But there are many eruptive springs in Iceland, and it is inconceivable that all of them should have caves and conduits so peculiarly constructed. This theory is therefore entirely untenable.

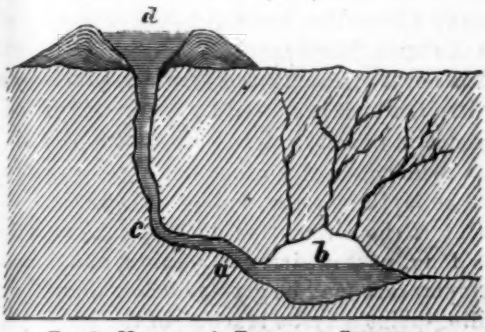


FIG. 7.—MACKENZIE'S THEORY OF ERUPTION.

The investigations of Bunsen and his theory of the eruption and the formation of geysers are among the most beautiful illustrations of scientific induction which we have in geology. We therefore give it, perhaps, more fully than its strict geological importance warrants.

Bunsen examined all the phenomena of hot springs in Iceland. 1. He ascertained that geyser-water is meteoric water, containing the soluble matters of the igneous rocks in the vicinity. He formed identical water by digesting Iceland rocks in hot rain-water. 2. He ascertained that there are two kinds of hot springs in Iceland, viz., *acid springs* and *alkaline-carbonate springs*, and that only alkaline-carbonate springs contain any silica in solution. The reason is obvious: alkaline waters, especially if hot, are the natural solvents of silica. 3. He ascertained that *only the silicated springs form geysers*. Here is one important step taken—one condition of geyser-formation discovered. Deposit of silica is necessary to the existence of geysers. The tube of a geyser is not an accidental conduit, but is built up by its own deposit. 4. Of silicated springs, *only those with long tubes erupt*—another condition. 5. Contrary to previous opinion, the silica in solution does not deposit on cooling, but only by drying. This would make the building-up of a geyser-tube an inconceivably slow process, and the time proportionally long. This, however, is not true, for the Yellowstone geyser-waters, which deposit abundantly by *cooling*, evidently because they contain much more silica than those of

Iceland. 6. The temperature of the water in the basin was found to be usually 170° to 180°, and that in the tube to increase rapidly, though not regularly, with depth. Moreover, the temperature, both at the surface and at all depths, increased regularly as the time of eruption approached. Just before the eruption it was, at the depth of about forty-five feet, very near the boiling-point *for that depth.*

1. It is well known that the boiling-point of water rises as the pressure increases. This is shown in the adjoining table. 2. It follows from the above that if water be under strong pressure, and at high temperature, though below its boiling-point for that pressure, and the pressure be diminished sufficiently, it will immediately flash into steam. 3. Water heated beneath, if the circulation be unimpeded, is *very nearly* the same temperature throughout. That it is never the same temperature precisely is shown by the circulation itself, which is caused by difference of temperature, producing difference in density. The phenomenon of simmering is also a well-known evidence of this difference of temperature, since it is produced by the collapse of steam-bubbles rising into the cooler water above. 4. But if the circulation be *impeded*, as when the water is contained in long, narrow, irregular tubes, and heated with great rapidity, the temperature may be greater below than above to any extent, and the boiling-point may be reached in the lower part of the tube, while it is far from this point in the upper part.

Pressure in Atmospheres.	Boiling-Point.
1 Atmos.	212°
2 "	250°
3 "	275°
4 "	293°

We will suppose a geyser to have a simple but irregular tube, without a cave, heated below by volcanic fires, or by still hot volcanic ejections. Now, we have already seen that the temperature of the water in the tube increases rapidly with the depth, but is, at every depth to which observation extends, short of the boiling-point for that depth. Let abscis *a d* (Fig. 8) represent depth in the tube, and also pressures; and the corresponding temperature be measured on the ordinate *a n*. If, then, *a b*, *b c*, *c d*, represent equal depths of thirty-three or more feet, which is equal to one atmospheric pressure, the curve *e f* passing through 210°, 250°, 275°, and 293°, at the horizontal lines, representing one atmosphere, two atmospheres, three atmospheres, etc., would correctly represent the increasing boiling-points as we pass downward. We shall call this line, *e f, the curve of boiling-point.* The line *a g* commencing at the surface at 180°, and gradually ap-

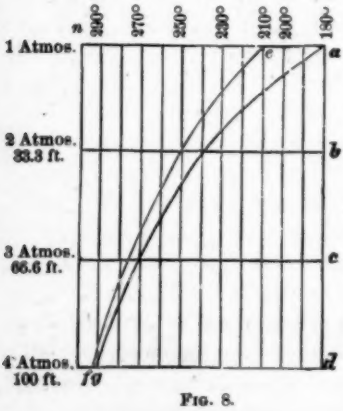


FIG. 8.

proaching the boiling-point line, but everywhere within it, would represent the actual temperature in a state of quiescence. Now, Bunsen found that, as the time of eruption approached, the temperature at every depth approached the boiling-point for that depth, i. e., the line *a g* moved toward the line *e f*. There is no doubt, therefore, that, at the moment of eruption, at some point below the reach of observation, the line *a g* actually touches the line *e f*—the boiling-point for that depth is actually reached. As soon as this occurs, a quantity of water in the lower portion of the tube, or perhaps even in the subterranean channels which lead to the tube, would be changed into steam, and the expanding steam would lift the whole column of water in the tube, and cause the water in the basin to *bulge and overflow*. As soon as the water overflowed, the pressure would be diminshed in every part of the tube, and consequently a large quantity of water before very near the boiling-point would flash into steam and instantly eject the whole of the water in the pipe; and the steam itself would rush out immediately afterward. The premonitory cannonading beneath is evidently produced by the collapse of large steam-bubbles rising through the cooler water of the upper part of the tube; in other words, it is *simmering on a huge scale*. An eruption is more quickly brought on by throwing stones into the throat of the geyser, because the circulation is thus more effectually impeded.

The theory given above is substantially that of Bunsen for the eruption of the Great Geyser, but modified to make it applicable to all geysers. In the Great Geyser, as already stated, Bunsen found a point, forty-five feet deep, where the temperature was nearer the boiling-point than at any *within* reach of observation, though doubtless *beyond* the reach of observation the temperature again approached and *touched the boiling-point*. This point, forty-five feet deep, plays an important part in Bunsen's theory. To illustrate: if *e f* (Fig. 9) represent again the curve of boiling-point, then the curve of actual temperature in the Great Geyser tube would be the irregular line *a g h*. At the moment of eruption, this line touched boiling-point at some depth, *h*, beyond the reach of observation. Then followed the lifting of the column, the overflow of the basin, the relief of pressure by which the point *g* was brought to the boiling-point, the instantaneous formation of steam at *g*, and the phenomena of an eruption. But it is extremely unlikely that this

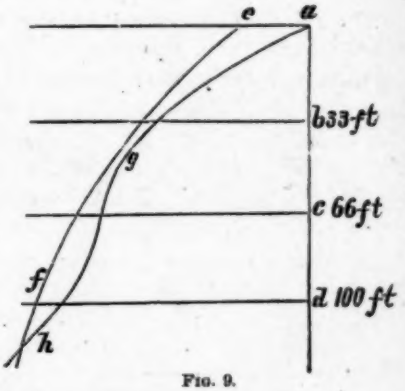


FIG. 9.

condition should exist in all geysers; neither is it at all necessary in order to explain the phenomenon of an eruption.

To prove beyond question the truth of his theory, Bunsen constructed an artificial geyser. The apparatus (Fig. 10) consisted of a tube of tinned sheet-iron about ten feet long, expanded into a dish above for catching the erupted water. It may or may not be expanded below for the convenience of heating. It was heated, also, a little below the middle, by an encircling charcoal chauffer, to represent the point of nearest approach to the boiling-point in the geyser-tube. When this apparatus was heated at the two points, as shown in the figure, the phenomena of geyser-eruption were completely reproduced; first, the violent explosive simmering, then the overflow, then the eruption, and then the state of quiescence. In Bunsen's experiment, the eruptions occurred about every thirty minutes.

Fig. 10.—Artificial Geyser.

According to Bunsen, a geyser does not find a cave, or even a perpendicular tube, ready made, but, like volcanoes, makes its own tube. Fig. 11 is an ideal section of a geyser-mound, showing the manner in which, according to this view, it is formed. The irregular line, *b a c*, is the original surface, and *a* the position of a hot spring. If the spring be not alkaline, it will remain an ordinary hot spring; but, if it be alkaline, it will hold silica in solution, and the silica will be deposited about the spring. Thus the mound and tube are gradually built up. For a long time the spring will not be eruptive, for the circulation will maintain a nearly equal temperature in every part of the tube—it may be a *boiling*, but not an eruptive spring. But, as the tube becomes longer, and the circulation more and more impeded, the difference of temperature between the upper and lower parts of the tube becomes greater and greater, until, finally, the boiling-point is reached below, while the water above is comparatively cool. Then the eruption commences. Finally, from the gradual failure of the subterranean heat, or from the increasing length of the tube repressing the formation of steam, the eruptions gradually cease. Bunsen found geysers in every stage of development—some playful springs without tubes; some with short tubes, not yet eruptive; some with long tubes, violently eruptive;

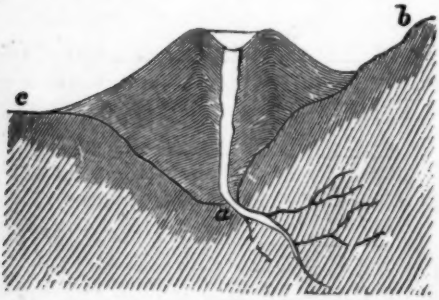


Fig. 11.—Ideal Section of a Geyser-Tube (according to Bunsen).

some becoming old and indisposed to erupt unless angered by throwing stones down the throat.

It is evident, however, that Bunsen's theory of geyser-eruption is independent of his theory of geyser-formation. A tube or fissure of any kind, and formed in any way, if long enough, would give rise to the same phenomena. The Yellowstone geysers have mounds or chimney-like cones, but it is by no means certain that the whole length of their eruptive tubes has been built up by siliceous deposit. Bunsen's theory of eruption none the less, however, applies to these also. The more chimney-like form of the craters in the case of the Yellowstone geysers is probably due to the greater abundance of silica in solution.

THE HYGIENIC INFLUENCE OF PLANTS.

By MAX VON PETTENKOFER.

THE animal kingdom is, as we know, dependent on the vegetable kingdom, which must have existed on the earth before men and animals could live upon it. We may, therefore, rightly call plants children of the earth. But, in so doing we use the language of metaphor, as when we speak of "Mother Earth." The earth does not directly bring forth either plants or animals. Every plant is the child of a mother-plant, descends from one of its own kind like ourselves; but plants derive their nourishment directly from earth, air, and water, and, although generated by plants, are nourished directly by the inorganic breasts of Nature, and imply no other organic life but their own. Had plants a voice, they would more correctly speak of "Mother Earth" than ourselves.

Plants live directly on the lifeless products of earth, and we live directly on the products of plants or on animals which live on them; our existence implies other organic life, and our nourishment is not derived so directly from the earth as that of plants. Since the vegetable world comes between us, *we* should rather call earth our grandmother than our mother. At all events it is an affectionate relationship.

We have a natural feeling of close affinity with the vegetable world, which expresses itself not only in our love of foliage and flowers, but in our fondness for metaphors derived from the vegetable world and its processes. If we were to reckon up how many metaphors in every-day life and in poetry are derived from the vegetable world, and how many from other spheres of Nature, we should find a great excess of the former.

Our material relations to plants are also very numerous. The question we are now concerned with is not what food or what medi-

cinal remedies plants provide us with, but the value of plants and plantations in dwellings and in the open air in conducing to health or preventing disease. We have given the subject very little consideration until quite recently, just as we have thought very little of the way in which the pleasures of the table, fine raiment, comfortable dwellings, and many other things, conduce to our well-being. Meanwhile we have been guided by our instincts, which, like Nature in general, have, on the whole, guided us rightly. Even now there is not much scientific knowledge on the subject; still there is a little, and something is gained when we begin seriously to reflect on anything, for knowledge is sure then to increase. All that man has ever aspired to and attained has always existed much earlier in idea than in reality. Ideas are never fully realized, as we all know, and it is only very gradually that they are realized at all.

It is generally asserted that vegetation purifies the air, and chiefly by three functions: firstly, because plants absorb carbonic acid; secondly, because under the influence of sunlight they exhale an equivalent in oxygen; and, lastly, because they produce ozone. These facts I need not demonstrate, as they have been placed beyond doubt by vegetable physiologists, chemists, and meteorologists. My task is to show what the direct sanitary effect of these three functions is.

I must at once state that none whatever can be proved to exist. And, as this assertion will contradict the prepossessions of many readers, I feel bound to prove my proposition.

As to carbonic acid, the first question is: What is the proper and normal proportion of this gas in the air, next how much more carbonic acid is contained in air which is notoriously bad; and, lastly, whether the air on a surface without vegetation contains essentially more carbonic acid than one having vegetation upon it?

The amount of carbonic acid in the open air has been often determined, and is confined within very narrow limits. It may be said—leaving severe storms or very thick fogs out of the question—to vary between three and four parts in each 10,000 of the volume of the air.

Experiments have also been made on the quantity of carbonic acid in apartments occupied by man, and it is generally taken as the criterion of the quality of the air, ventilation being regulated by it. In very bad air which is undoubtedly deleterious, it has been found to amount to from three to five per mille. One per mille marks the boundary-line between good and bad air in a room.

We next inquire whether the atmosphere over a vast tract of country destitute of vegetation contains more carbonic acid than one abounding in vegetation, whether in the former case the amount of carbonic acid approaches one per mille. In 1830 De Saussure began to make researches into the variations in the quantity of carbonic acid in Geneva, and they were continued about ten years later by Verver in Holland, and Boussingault in Paris; in more recent, and

very recent times, a great number of experiments have been made on the subject by Roscoe in Manchester, Schulze at Rostock, and myself and my pupils, particularly Dr. Wolffhügel, at Munich. The result is, in the main, that the variations—very small from the first—have been found to be still smaller as the methods of determining carbonic acid have been perfected.

Saussure, who worked by a method liable to give an excess, found from 3.7 to 6.2 parts in 10,000. He considered that there were also slight variations between summer and winter, day and night, town and country, land and sea, mountains and valleys, which might be ascribed to vegetation. Boussingault, however, found the carbonic acid in the air to be rather less, and the same on an average in Paris and St.-Cloud; in Paris 4.13 and at St.-Cloud 4.14 in 10,000, which surprised him the more as he had reckoned that in Paris at least 2,944,000,000 litres of carbonic acid were exhaled by men, animals, and fuel.

Roscoe made experiments on the air at a station in the middle of Manchester, and at two stations in the country. He was originally of opinion that the vast manufactures of Manchester, chiefly dependent on the consumption of coal, must produce a perceptible effect on the carbonic acid in the air; but he also discovered that the air in the space in front of Owens College contained no more than the air at the country stations. He also observed occasional variations: but, when the carbonic acid increased or diminished in the city, it was generally just the same in the country. Roscoe found the greatest amount of carbonic acid in the air during one of the thick fogs prevalent in England.

Schulze found the amount of carbonic acid in the air at Rostock to be between two and half and four parts in 10,000. On an average it was somewhat higher when the wind blew off-shore than off the sea.

In Munich, Wolffhügel found the carbonic acid to be between three and four parts in 10,000. Now and then, but very seldom, he observed variations, the maximum being 6.9 parts in 10,000 in a very thick fog, the minimum 1.5 part in 10,000 in a heavy snow-storm, when the mercury was very low in the barometer.

It may be asked how the immense production of carbonic acid in a city like Paris or Manchester can thus vanish in the air. The answer is very simple: by rarefaction in the currents of the atmosphere. We are apt not to take this factor into account, but think rather of the air as stagnant. The average velocity of the air with us is three metres per second, and even in apparently absolute calm it is more than half a metre. If we therefore assume a column of air 100 feet high and of average velocity, it may be reckoned that the carbonic acid from all the lungs and chimneys of Paris or Manchester is not sufficient to increase its amount so as to be detected by our methods.

From this fact it may be logically concluded that, if no increase

in the carbonic acid in the air is observable, no diminution will be observable from vegetation.

It is a universally recognized and incontrovertible fact that the carbonic acid contained in all the vegetable life on earth is derived from the carbonic acid in the air, in water, and the soil. Many conclude, therefore, that the air in a green wood must contain less carbonic acid than that in a city or that of an extensive tract of waste land. But I can assure them that the air in the Sahara, so called, of Munich, formerly called the Dultplatz, contains no more carbonic acid than the neighboring Eschen-grounds. Of this I can give incontestable proof, an argument *ad hominem*. Dr. Zittel brought me several specimens of air in hermetically-sealed glass tubes, from his travels in the Libyan Desert, from sandy wastes and from oases, on which I could conveniently make experiments at Munich. The amount of carbonic acid does not differ in the least in the air from the barren waste and the greenest oases. The case is just the same with the amount of oxygen in the air. It was formerly thought, when imperfect methods were employed, that perceptible variations could be proved. Thus, for example, the outbreak of cholera in 1831 was attributed to a diminution of oxygen in the air, and here and there experiments were made which seemed to confirm the opinion. The hypothesis did not seem improbable, for it was concluded with certainty that in tropical swamps, which are the home of cholera, the oxygen in the air might have been in course of time diminished by the vast masses of decaying matter. But, since the method of gas analysis has been arranged by Von Bunsen, the amount of oxygen in the air on the summit of Mont Blanc has not been found to differ from that in a city or in the swamps of Bengal. Neither is it greater in forest or sea air than in the air of the desert.

This absence of demonstrable variation, in spite of the production of oxygen by living plants and the absorption of it by the processes of combustion and decay, becomes intelligible when we consider first the mobility, and then the mass of the air encompassing our earth. The weight of this mass is, as the barometer tells us, equal to that of a layer of mercury which would cover the surface of the earth to the depth of 760 millimetres (more than three-quarters of a metre). From the weight of this, several billion kilometres, some idea can be formed of the volume of the air, when we consider that air, even beneath a pressure of 760 millimetres of mercury, is yet 10,395 times lighter than mercury. In masses like these, variations such as those we speak of go for nothing. The amount of carbonic acid and oxygen might perhaps be essentially changed in Paris or Manchester if all organic matter on and in the earth were burning at once.

Even if it is granted, however, in face of these incontrovertible facts, that vegetation exercises no perceptible influence upon the composition of the atmosphere in the open air, many persons will not be

disposed to give up the idea that the air in rooms can be improved by plants, because, as is well known, every green leaf absorbs carbonic acid and gives out oxygen under the influence of light. This idea may seem the more justifiable, because, although the production of carbonic acid is not perceptible in the greatest assemblages of human beings in the open air, it is always observed in confined spaces, although the actual production is but small. In the air of a closed apartment, every person and every light burning makes a perceptible difference in the increase of carbonic acid in the air. Must not, therefore, every plant in a pot, every spray, any plant with leaves, make a perceptible difference in a room? Every lover of flowers may be pardoned for wishing to see this question answered in the affirmative. Have not even medical men proposed to adorn school-rooms with plants in pots instead of ventilating them better, in order that their leaves and stems might absorb carbonic acid from the mouths of the children, and give out oxygen in its stead? But hygiene cannot agree even to this. Hygiene is a science of economics, and every such science has to ask not only what exists and whether it exists, but how much there is and whether enough. The power of twenty pots of plants would not be nearly sufficient to neutralize the carbonic acid exhaled by a single child in a given time. If children were dependent on the oxygen given off by flowers, they would soon be suffocated. It must not be forgotten what a slow process the production of matter by plants is—matter which the animal organism absorbs and again decomposes in a very short time, whereby as much oxygen is used up as has been set free in the production of it. It is for this reason that such great extents of vegetation are required for the sustenance of animals and man. The grass or hay consumed by a cow in a cow-house grows upon a space of ground on which a thousand head of cattle could stand. How slow is the process of the growth of wheat before it can be eaten as bread, which a man will eat, digest, and decompose, in twenty-four hours! The animal and human organism consumes and decomposes food as quickly as a stove burns the wood which took so many thousand times longer to grow in the forest.

It would scarcely be intelligible if I were to calculate how much carbonic acid and oxygen a rose, a geranium, or a bignonia, would absorb and give out in a room in a day, and to what extent the air might be changed by it, taking into account the inevitable change of air always going on. I will draw attention to a concrete case which every one can understand:

When the Royal Winter Garden in Munich was completed and in use, it occurred to me to make experiments on the effect of the whole garden on the air within it. There could not be a more favorable opportunity for experimenting on the air in a space full of vegetation. This green and blooming space was not exposed to the free currents

of air which at once immensely rarefy all gaseous exhalations, but was kept warm under a dome of glass, through which only the light of heaven penetrated. Although not hermetically sealed, the circulation of air in such a building, compared with that in the open air, is reduced over a hundred-thousandfold.

I asked permission to make experiments for several days at various hours of the day and night, which was readily granted. Now, what was the result? The proportion of carbonic acid in the air in the winter garden was almost as high as in the open air. This greatly surprised me, but I hoped at any rate to have one of my traditional ideas confirmed: I hoped to find less carbonic acid in the day than in the night, supported by the fact that the green portions of plants under the influence of light decompose carbonic acid and develop oxygen. But even here I was disappointed. I generally found carbonic acid increasing from morning till evening, and decreasing from night till morning. As this seemed really paradoxical, I doubled my tests and care, but the result remained the same. At that time I knew nothing of the large amount of carbonic acid of the air, in the soil, the air of the ground, or I should probably have been less surprised.

One day it suddenly became clear to me why there was always more carbonic acid by day than by night. I had been thinking only of the turf, the shrubs, and trees, which consume carbonic acid and produce oxygen, and not of the men and birds in the winter garden. One day, when there were considerably more men at work there than usual, the carbonic acid rose to the highest point, and sank again to the average during the night. The production of carbonic acid by the working and breathing of human beings was so much greater than that consumed by the plants in the same time.

The oxygen in the winter garden was rather higher than in the open air; there it was about twenty-one per cent., and in the winter garden twenty-two to twenty-three per cent.

I did not make any experiments on ozone, for reasons which I will give by-and-by.

The amount of carbonic acid in the air in the winter garden cannot be reckoned as telling for or against the hygienic value of vegetation in an inclosed space. Let us inquire, then, into the value of the slight increase of oxygen.

There is a wide-spread opinion that the breathing of air rich in oxygen effects a more rapid transformation of matter, a more rapid combustion, as we say, in the body. Even great inquirers and thinkers have considered that we only eat and imbibe nourishment to satiate the oxygen streaming through us, which would otherwise consume us. We know now well enough that the quantity of oxygen which we imbibe does not depend on the quantity in the air we breathe, but far more on previous changes in and the amount of

transformation of matter in the body, which are regulated by the requirements of breathing. The inhalation of oxygen is not a primary but a secondary thing. When we inhale air at every breath richer than usual in oxygen—for example, when breathing highly-compressed air, as divers do, or laborers on the pneumatic foundations of bridge-piers—the result is not a larger comsumption of matter and an increased production of carbonic acid, but merely a decrease in the number of inhalations. If in air of ordinary density we make about sixteen respirations in a minute, in air of greater density we should involuntarily make only twelve, ten, or eight, according to the density and our need of oxygen; all else remains the same.

Lavoisier, and, half a century later, Regnault and Reiset, placed animals for twenty-four hours in air very rich in oxygen, but they did not consume more of it than in the ordinary air. An increase of oxygen in the air, therefore, or pure oxygen gas, only produces an effect in certain morbid conditions, in cases of difficulty of breathing, or where breathing has been for some time suspended, because an inspiration communicates more oxygen to the blood than breathing ordinary air. A healthy person can, however, without difficulty or injury, compensate for considerable differences, and an increase or decrease of one or two per cent. of oxygen does no harm, for under ordinary circumstances we only inhale one-fourth of the oxygen in the air we breathe; we inhale it with twenty-one per cent. and exhale it with sixteen per cent.

So far, therefore, as we feel ill or well in a winter garden, it does not depend on the quantity of oxygen in the air, and there is no greater appreciable quantity of oxygen in a wood of thick foliage than in a desert or on the open sea.

Let us also for a moment consider the ozone in the air, which may be looked upon as polarized or agitated oxygen. After its discovery, which has immortalized the name of Schönbein, was made known, it was thought for a time that the key had been found for the appearance and disappearance of various diseases, in the quantity of ozone in the air. But one fact, which was observed from the first, shows that it cannot be so; for the presence of ozone can never be detected in our dwellings, not even in the cleanest and best ventilated. Now, as it is a fact that we spend the greater part of our lives in our houses, and are better than if we lived in the open air, the hygienic value of ozone does not seem so very great. Added to this, the medical men of Königsberg long had several ozone-stations there, during which time various diseases came and went, without, as appears from the reports of Dr. Schiefferdecker, ozone having the slightest connection with the appearance or disappearance of any of them.

Dr. Wolfhügel, assistant at the Hygienic Institute at Munich, has lately been occupied with the question of the sanitary value of ozone, but has arrived at only negative results.

But in saying this I have no intention of denying that ozone is of great importance in the atmosphere, for I am of opinion that it is. It is the constant purifier of the atmosphere from all organic matter, which passes into it and might accumulate. The air would have been long ago filled with the vapors of decomposition if it were not for ozone, which oxidizes all that is oxidizable, if only time enough is allowed for it, and too much is not expected at once; for, generally, the amount of ozone in the air is so small that it is consumed in making its way into our houses, without disinfecting them, and we can no more dispense with the greatest cleanliness and best ventilation in our homes than we can essentially change the air in our rooms by means of plants in pots and foliage.

Some of my readers will perhaps ask in some disappointment, "In what, then, does the hygienic value of plants and plantations consist? Or do I mean to say that all the money spent by one and another on a parterre of flowers in his house or on a garden, or by a community for beautiful grounds, or by a state for the preservation of forests, with the idea of promoting health, is mere luxury, without any hygienic value?" These questions alter our standpoint, and I believe I shall be able to show that even hygiene does recognize a sanitary value in plants and flowers, in the laying out of grounds and plantations, only it offers a different explanation from the ordinary one.

I consider the impression which plants and plantations make upon our minds and senses to be of hygienic value; further, their influence on the conformation of the soil, with which health is in many respects connected; and, finally, their influence upon other qualities of the air, than carbonic acid, oxygen, and ozone: among these may be mentioned, in passing, shade in summer, and decrease of wind and dust.

It is an old observation, needing no demonstration, that the cheerful and happy man lives not only an easier, but, on the average, a more healthy life than the depressed and morose man. Medical men, and especially "mad doctors," could tell us much of the great value of a certain relative proportion of pleasurable and painful impressions upon health, and how frequently some unfortunate position, an absence of pleasure, or too much of painful impression, is the cause of serious illness. Man always tries, and has an irresistible need, to balance painful sensations by some kind of pleasure or other, so that often, in order to get himself into a tolerable frame of mind, or to deaden his feelings for a time, he will have recourse to wine, beer, or spirits, though he knows well enough that he will be worse afterward than before. A certain amount of change and recreation is indispensable, and, failing others, we seek them by injurious means. There are, doubtless, some unhappy and morbid natures who are always discontented, to whom everything comes amiss, and whom it is impossible to help; but the majority of men are easily pleased, find pleasure in little things, though it is but a sorry life they lead. It

is something the same with the pleasures of life as with the pleasures of the table; we must relish our food if it is to do us good. What good will the most nourishing diet do me if it creates disgust? Prof. C. Voit has clearly pointed out, in his experimental researches into diet, the great value of palatable food, as well as nourishment, and how indispensable a certain variety in our meals is. We think we are only tickling the palate, and that it is nothing to the stomach and intestines whether food is agreeable to the palate or not, since they will digest it, if it is digestible at all. But it is not so indifferent, after all; for the nerves of the tongue are connected with other nerves and with the nerve-centres, so that the pleasures of the palate, or some pleasure, at any rate, even if it is only imagination, which can only originate in the central organ, the brain, often has an active effect on other organs. This is a matter of daily experience. If you put your finger down your throat, you produce retching; many people have only to think of anything disgusting to produce the effect of an emetic, just as the thought of something nice makes the mouth water just as much as tasting the most dainty morsel. Voit showed me one of his dogs with a fistula in the stomach. So long as this dog is not thinking of food, his stomach secretes no gastric juice, but no sooner does he catch sight of a bit of meat, even at a distance, than the stomach prepares for digestion and secretes gastric juice in abundance. Without this secretion the assimilation of nourishment would be impossible. If, therefore, some provocatives induce and increase certain sensations and useful processes, they are of essential value to health, and it is no bad economy to spend something on them.

I consider flowers in a room, for all to whom they give pleasure, to be one of the enjoyments of life, like condiments in food. It is certainly one of the most harmless and refined. We cannot live on pleasure alone; but, to those who have something to put up with in life, their beloved flowers perform good service.

The same may be said of private gardens and public grounds, and of the artistic perfecting of them. The more tastefully laid out, the better the effect. Though tastes differ, there is a general standard of taste which lasts for several generations, though it varies from time to time, and is subject to fashion. As their object is to give pleasure, public grounds should accord with the taste of the age, or aim at cultivating it. This is a justification for going to some expense for æsthetic ends.

The influence of vegetation on the soil is much more easy to determine than on the mind of man. Space fails me to go into all the aspects of this subject, and I will confine myself to some of the most obvious. The difference is most apparent on comparing the soil of a tract of land covered with wood with the soil outside, in other respects alike. The Bavarian Forest Department deserves great credit for having established meteorological stations with special reference to

forest-culture, under the superintendence of Prof. Ebermayer, of Aschaffenburg. He has published his first year's observations in a work on "The Influence of Forests on the Air and Soil, and their Climatic and Hygienic Importance,"[1] which may be recommended to every one who wishes to study the subject.

Modern hygiene has observed that certain variations in the moisture of the soil have a great influence on the origin and spread of certain epidemic diseases, as for instance cholera and typhoid fever—that these diseases do not become epidemic when the moisture in the soil is not above or below a certain level, and has remained so for a time. These variations can be measured with greater accuracy by the ground-water of the soil than by the rainfall, because in the latter case we have to determine how much water penetrates the ground, how much runs off the surface, and how much evaporates at once. The amount of moisture in the soil of a forest is subject to considerably less variation than that outside. Ebermayer has deduced the following result from his meteorological observations on forestry: "If from the soil of an open space 100 parts of water evaporate, then from the soil of a forest free from underwood 38 parts would evaporate, and from a soil covered with underwood only 15 parts would evaporate." This simple fact explains clearly why the cutting down of wood over tracts of country is always followed by the drying up of wells and springs.

In India, the home of cholera, much importance has been attached in recent times to plantations as preventives of it. It has been always observed that the villages in wooded districts suffer less than those in treeless plains. Many instances of this are given in the reports of Dr. Bryden, President of the Statistical Office in Calcutta, and Dr. Murray, Inspector of Hospitals. For instance, Bryden[2] compares the district of the Mahanadda, one of the northern tributaries of the Ganges, the almost treeless district of Rajpoor, with the forest district of Sambalpoor. It is stated that in the villages in the plain of Rajpoor, sixty or seventy per cent. of the inhabitants are sometimes swept away by cholera in three or four days, while the wooded district of Sambalpoor is often free from it, or it is much less severe. The district commissioner, who had to make a tour in the district on account of the occurrence of cholera, reports, among other things, as follows:

"The road to Sambalpoor runs for sixty or seventy miles through the forest, which round Petorah and Jenkfluss is very dense. Now, it is a remarkable fact, but it is a fact, nevertheless, that on this route, traversed daily by hundreds of travelers, vehicles, and baggage-trains, the cholera rarely appears in this extent of sixty miles, and when it does appear it is in a mild form; but when we come to the road from Arang, westward to Chicholee Bungalow, which runs for about

[1] "Die physikalischen Wirkungen des Waldes auf Luft und Boden und seine klimatologische und hygienische Bedeutung."

[2] "Epidemic Cholera in the Bengal Presidency," 1869, p. 225.

ninety miles through a barren, treeless plain, we find the cholera every year in its more severe form, the dead and dying lying by the wayside, and trains of vehicles half of whose conductors are dead."

In the same report Dr. Bryden continues:

"I will mention one other fact as a result of my observations, namely, that places surrounded by those vast and splendid groves which are occasionally seen, lying in low and probably marshy situations, surrounded by hills, and which, from the mass of decaying vegetation, are very subject to fever in September, October, and November, are seldom visited by cholera, and if it occurs there are but few deaths, while places on high ground, or in what are called fine, airy situations, free from trees and without hills near, so that they are thoroughly ventilated, suffer very much from cholera."

Murray gives a number of instances showing the influence of trees on the spread of cholera. One of these may find a place here:

"The fact is generally believed, and not long ago the medical officer of Jatisgar, in Central India, offered a striking proof of it. During the wide-spread epidemic of cholera in Allahabad, in 1859, those parts of the garrison whose barracks had the advantage of having trees near them enjoyed an indisputable exemption, and precisely in proportion to the thickness and nearness of the shelter. Thus the European Cavalry in the Wellington Barracks, which stand between four rows of mango trees, but are yet to a certain extent open, suffered much less than the Fourth European Regiment, whose quarters were on a hill exposed to the full force of the wind; while the Bengal Horse Artillery, who were in a thicket of mango-trees, had not a single case of sickness; and the exemption cannot be regarded as accidental, as the next year the comparative immunity was precisely the same." [1]

We need not, however, go to India to observe similiar instances of the influence of a certain degree of moisture in the soil favored by woods or other conditions; we can find them much nearer home. In the cholera epidemic of 1854, in Bavaria, it was generally observed that the places in the moors were spared, in spite of the otherwise bad condition of the inhabitants. The great plain of the Danube from Neuburg to Ingolstadt was surrounded by places where it was epidemic, while in the plain itself there were but a few scattered cases. The same thing has been demonstrated by Reinhard, President of the Saxon Medical College. Cholera has visited Saxony eight times since 1836, and every time it spared the northerly district between Pleisse and Spree, where ague is endemic.

In the English Garden at Munich there are several buildings, not sparsely tenanted—the Diana Baths, the Chinese Tower, with a tavern and out-buildings, the Gendarmerie Station, and the Kleinkesselhohe. In the three outbreaks of cholera at Munich none of these places have been affected by it. This fact is the more surprising, as three of them comprise public taverns into which the disease germs must have been occasionally introduced by the public; yet there was

[1] "Report on the Treatment of Epidemic Cholera," 1869, p. 4.

no epidemic in these houses, although it prevailed largely immediately beyond the English Garden and close to the Diana Baths in 1854 and 1873. It must have been accidental that no isolated cases occurred, as the inmates of the Chinese Tower, or the Kleinkessellohe, might have caught it in Munich as others did who came from a distance, but, had there been single cases, probably no epidemic would have occurred in these houses.

Even if these deductions must be accepted with caution from an etiological point of view, still, on the whole, they indisputably tell in favor of trees and woods.

Surface vegetation has also other advantages, besides its use in regulating the moisture in the soil; it purifies it from the drainage of human habitations, whereby it is contaminated and impregnated. If this refuse matter remains in soil destitute of growing vegetation, further decomposition sets in, and other processes are induced, not always of a salubrious nature, but often deleterious, the products of which reach us by means of air or water, and may penetrate into our houses. But from this indisputable fact false conclusions are sometimes drawn. Many people imagine that if a few old trees are left standing in an open space their roots will absorb all the impurities from the houses around, and render the refuse which accumulates beneath them innocuous. This idea is not only false in a sanitary point of view, but very injurious, as it prevents people from taking the measures which alone can keep the ground under our houses pure.

We will now explain why the shade of gardens and woods is at certain seasons so beneficial. The human race during its pilgrimage on earth and wanderings over it has many difficult tasks to perform. One of the most difficult is involved in the necessity that all our internal organs, and the blood, whether at the equator or the north-pole, should retain an equable temperature of 37½° Centigrade (98° Fahr.). Deviations of but one degree are signs of serious illness. The blood of the negro and that of the Esquimaux is of the same temperature, while the one lives in a temperature of 40° above, and the other 40° below zero (Centigrade). A difference of 80° has therefore to be equalized.

Our organism, doubtless, possesses a special apparatus for the performance of this colossal task, self-acting sluices so to speak, by means of which more or less of the heat generated in the body passes off: these consist mainly in the increase or diminution of the peripheric circulation, and the action of the pores of the skin. But we soon come to the end of our natural regulating apparatus, and have to resort to artificial means. Against cold we have excellent methods in clothing, dwellings, and fires; but at present our precautions against heat are very limited. This is, doubtless, the reason why higher civilization has extended so much farther toward the polar regions than toward

the equator. The Germanic races, particularly, inevitably degenerate after living for a few generations in the tropics, and must be continually renewed by immigration if they desire to retain supremacy, as is proved by the case of the English in India. They will not be able to settle there and maintain the characteristics which have made them dominant, until means have been found of diminishing the heat of the body at pleasure, as we are able to maintain it in the north. At present our remedies against heat are baths, fans, and shade.

We lose the heat of our bodies in three different ways: by the medium in which we are, generally the air, and which can be warmed; by the evaporation of perspiration; and by radiation from bodies of a lower temperature, not taking into account a small portion of heat which goes off in mechanical labor. Under ordinary circumstances in temperate climates, we lose half the heat generated by radiation, one-fourth by evaporation, and one-fourth by the conducting medium in which we are. In proportion as any of these methods is diminished, one or both the others must be increased. As long as possible, our organisms are so obliging as to open and close the sluices themselves without our cognizance, provided that our regulating apparatus is in order, that we are not ill. It is only when our good servant the skin, under certain conditions, has come to an end of its powers, that we begin to feel that we must lend our aid. And thus we have found by experience that, in hot weather, shade helps the body to keep cool to the needful extent. The chief effect of shelter is to prevent the sun's rays from striking us directly; but, if this were all, it would be as cool in the height of summer in-doors, or even under the leaden roofs of Venice, which have driven many to frenzy and desperation, as under the shade of a tree or in a wood. It also makes a great difference whether the sun's rays fall on thick foliage or on a roof of slate or metal. A great deal of heat is neutralized by evaporation from the leaves; another portion by the decomposition of carbonic acid, just so much as is set free when we burn the wood and other organic combinations into the composition of which it enters. The heat produced by burning wood in a stove is derived from the sun; it is but the captured rays of the sun again set free by combustion. We learn from Ebermayer's work that the temperature of the trees in a forest, and even in the tops of them, is always lower than the air in the forest.

Besides this, shade in the open air always causes a certain draught which acts as a kind of fan. All must have noticed when walking in oppressive heat, when the air seems still as death, that a refreshing breeze arises as soon as a cloud casts a shade. The same thing may often be observed in summer in walking through a street with close rows of houses, when the air is still, and one side is sunny, the other in shade. On the sunny side there is not a breath of air, while on the other there may be a light breeze. This is easily explained; so far as

the shade extends the air is cooler than in the sun; layers of air of unequal warmth are of different gravity, and this difference of temperature is the cause of the motion in the air.

The shade of a single tree, therefore, cools not only by intercepting the sun's rays, but also by the effect of gentle fanning. The shelter of a thick wood, however, is much more agreeable than that of a single tree. The air in a wood is cooler than that of an open space exposed to the sun. The air from outside is drawn into the wood, is cooled by it, and cools us again. And it is not only the air that cools us, but the trees themselves. Observation has shown that the trunks of trees in a wood breast-high, even at the hottest time of day, are 5° Centigrade cooler than the air. We therefore lose considerable heat by radiation to these cooler objects, and can cool ourselves more easily at a temperature of 25° Centigrade in a wood than at a much lower temperature in an open space. When the objects around us are as warm as ourselves we lose nothing by radiation; what is radiated from us is radiated back by them. This is why we are so uncomfortable in heated and overcrowded rooms. It is generally set down to bad air, and this does certainly contribute to it, but it is chiefly the result of disturbed distribution of heat, as has been plainly shown by experiments on the composition of such air, which makes many people feel ill.—*Contemporary Review.*

COUNTING BY THE AID OF THE FINGERS.

By Prof. JOHN TROWBRIDGE.

ONE cannot with any reason contend that the universal possession of ten fingers argues a natural tendency of the human mind toward the decimal system; it is certainly true, however, that multitudes of men and women find their fingers of great assistance in arithmetical operations. The intelligent school-teacher is apt to discourage the pupil's use of the fingers in addition, and to encourage mental counting without their aid. I have been interested to discover the nature of this mental process which goes on apparently without the aid of the hands. From questioning a large number of persons, I find that five or six is the limit to the numbers of things which one can repeat, and also keep the count. Of course, this limit can be much exceeded by practice; one person who was interrogated could count up to fifty, but he was an astronomer. Most persons reply to the interrogatory, "How do you keep the count?" by saying, "I run up to five, and then again to five, and so on." In most cases it was found that a subdivision into ones and twos preceded this division into fives. The division into twos seemed to be the most common; by

accenting every second number it is not difficult to run up to six or eight, and still keep the count. In reflecting upon the answers to my interrogatories, I was led to believe that the possession of ten fingers was not the only cause of our counting by fives and tens, but that a certain rhythm in a system of counting by twos enabled us to overcome a resistance to memory.

This point can be elucidated in the following manner: If we desire to keep the count of the letters of the alphabet while we repeat their names, we can arrange them advantageously in a system of squares separated by a clamp of two, as in Fig. 1. Here we have a system of twos counting up to ten. A system of mental squares, so to speak, is formed, which enables us to hold the numbers apart, and to form a distinct classification. This system is capable of much extension: for instance, we

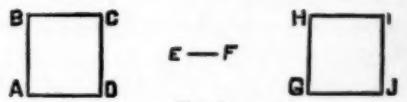


Fig. 1.

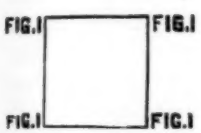


Fig. 2.

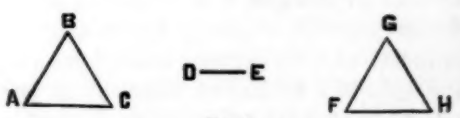


Fig. 3.

can readily form another square in which a mental diagram like Fig. 1 is placed again at the four corners of a square, giving us forty; and the system of squares is capable of much further extension before the mind becomes confused and loses its count. In repeating these diagrams in the mind, a certain rhythm will be perceived which is wanting when we use the system of triangles which is represented in Fig. 3, or a system of pentagons or hexagons. Indeed, with the last-named figures great mental confusion speedily arises; the mental resistance to holding a clear image of a square or triangle in the mind is much less than that which arises when we wish to behold mentally a pentagon or a hexagon.

It would not be difficult to prove a close relation between the forms of verse and the instruments by which a mathematician mounts to the expression of thought. The commonest forms of verse are written in four or five feet. In reading such lines the memory retains the rhythm and the words of each line without effort. When, however, we increase the number of feet in the verse, their length becomes cumbrous and the memory flags. No system of squares or triangles can obviate this difficulty. A system of geometrical mnemonics could undoubtedly be based upon the preceding exemplifications.

In the early dawn of human knowledge the arrangement of points in squares and triangles, and the further conception of areas by their subdivision into triangles, undoubtedly arose from the inability of the

human mind to retain distinct images of figures more complicated than rectangles or squares. In the case of curved lines, the mind has a tendency to refer all arcs to circles, since a circle forms as definite a conception as a square. The fact that it is made up of an infinite number of straight lines has significance only to a geometer.

MODERN LIFE AND INSANITY.

By DANIEL HACK TUKE, M. D.

THE relation between modern civilized life and insanity cannot be regarded as finally determined while a marked difference of opinion exists in regard to it among those who have studied the subject; nor can this difference be wondered at by any one who has examined the data upon which a conclusion must be formed, and has found how difficult it is to decide in which direction some of the evidence points. Statistics alone may prove utterly fallacious. Mere speculation, on the other hand, is useless, and indeed is only misleading. It is a matter on which it is tempting to write dogmatically, but where the honest inquirer is quickly pulled up by the hard facts that force themselves on his attention. Nothing easier than to indulge in unqualified denunciations of modern society; nothing more difficult than a cautious attempt to connect the social evils of the present day with the statistics of lunacy. Nothing easier than to make sweeping statements without proof, nothing more difficult than to apportion the mental injury respectively caused by opposite modes of life; totally diverse social states of a nation often leading to the same termination—insanity. These are closely bound together in the complex condition of modern civilized society. No doubt if we care for truth, and avoid rash assertions, we do it at the expense of a certain loss of force and incisiveness. Dogmatic statements usually produce more effect than carefully-balanced and strictly logical positions. Honesty, however, compels us to speak cautiously, and to confess the difficulties to which we have referred.

We shall not enter at length into the question which is at once raised by an inquiry into the relation between modern life and insanity—whether lunacy is on the increase in England. Twenty years ago there was one lunatic or idiot officially reported to 577 of the population; the latest returns place it as high as one in 370. Were we to go further back, the contrast would be far greater. That the increase of known cases of insanity has been very great, no one, therefore, disputes. Further, that the attention paid to the disease; the provision made for the insane; the prolongation of their lives in asylums, and the consequent accumulation of cases, and other circum-

stances into which our limits forbid us to enter, account for the greater part of this alarming apparent increase, is certain. Whether, however, there is not also an actual increase, unaccounted for by population, or by accumulation, remains an open question, which statistics do not absolutely determine. At the same time we think that it is quite probable that there has been some real increase.

To what social class do the great mass of our lunatics belong, and to what grade of society does the striking apparent increase of the insane point? The large majority of lunatics under legal restraint undoubtedly belong to the pauper population. On the 1st of January, 1877, of the total number of patients in asylums and elsewhere (in round numbers 66,600), about 59,000 were pauper, and only 7,600 private patients. These figures, however, fail to convey a correct statement of the relative amount of insanity existing among the class of the originally poor and uneducated masses and the class above them, because in a considerable number of instances members of the middle and still higher classes have become paupers. Again, the wealthy insane remain very frequently at home, and do not appear in the official returns. We believe this class to be very large. Probably we get a glimpse of it from the census of 1871, which contained 69,000 lunatics, idiots, and imbeciles (and we have good reasons for knowing that this return was very far short of the truth), yet it exceeded the number given by the Lunacy Commissioners in the same year by 12,000! A large number no doubt lived with their families because these could well afford to keep them at home. None would be in receipt of relief, or they would have appeared in the Commissioners' Report. Another most important qualifying consideration remains—*the relative numbers of the classes of society from which the poor and the well-to-do lunatics are derived.* Several years ago the Scotch commissioners estimated the classes from which private patients are derived at only about an eighth of the entire population of Scotland; a proportion which would make them at least as relatively numerous as the pauper lunatics. No doubt in England the corresponding class of society is a larger one; but whatever it may be,[1] a calculation based upon the relative proportion of different social strata in this country would vastly reduce the apparent enormously different liability to insanity among the well-to-do and the poorer sections of the community, although, with this correction, the pauper lunatics would still be relatively in the majority.

The disparity between the absolute number of pauper and private

[1] We are informed by Dr. Farr that the proportion between the upper and middle classes on the one hand, and the lower classes on the other, is as 15 to 85. Calculated on this basis, the proportion of private and pauper lunatics to their respective populations would be one in 484 for the former, and one in 353 for the latter—a very different result from that obtained by the usual method of calculating the ratio of private and pauper lunatics to the whole population, viz., one in 3,231, and one in 415.

patients has greatly increased in recent years. In other words, the apparent increase of insanity is mainly marked among those who become pauper patients. This is certainly in great measure accounted for by the disproportionate accumulation of cases in pauper asylums, for reasons into which it is not now needful to enter. It assuredly does not prove that there has been anything like a corresponding growth of insanity among the poor as compared with the rich.

In any case, however, the illiterate population does yield a very serious amount of insanity, and the fact is so patent that it shows beyond a doubt that ignorance is no proof against the inroads of the disease. The absence of rational employment of the mental powers may lead to debasing habits and to the indulgence in vices especially favorable to insanity, less likely to attract a mind occupied with literary and scientific pursuits. No doubt mental stagnation is in itself bad, but the insanity arising out of it is more frequently an indirect than a direct result. If a Wiltshire laborer is more liable to insanity than other people, it may be not merely because his mind is in an uncultivated condition, but rather because his habits,[1] indirectly favored by his ignorance, and the brain he inherited from parents indulging in like habits, tend to cause mental derangement. It is conceivable that he might have had no more mental cultivation, and yet have been so circumstanced that there would have been very little liability to the disease. This distinction is extremely important if we are tracing causes, however true it would remain that ignorance is a great evil. A South-Sea islander might be much more ignorant than the Wiltshire laborer, and yet not be so circumstanced that he would be likely to transgress the laws of mental health. The ignorance of an African tribe and that of a village in Wilts may be associated, the one with very little, the other with very much lunacy. Mr. Bright's "residuum" of a civilized people and a tribe of North American Indians are alike uneducated, but, notwithstanding, present totally different conditions of life. We have no doubt that in a civilized community there will always be found by far the larger number of insane persons. There are three grand reasons for this. First, because those who do become insane, or are idiotic among savages, "go to the wall" as a general rule; the other reasons are to be discovered in the mixed character and influence of European civilization; its action on the one hand in evolving forms of mental life of requisite delicacy and sensibility, easily injured or altogether crushed by the rough blasts from which they cannot escape in life; and on the other hand in producing a state confounded, as we have said, with savagery, but which differs widely from it, and is, simply in relation to mental disorders, actually worse. Recklessness, drunkenness, poverty, misery, charac-

[1] Dr. Thurnam, the late superintendent of the Wilts County Asylum, found that the proportion of cases caused by drink in this county was very high—in one year (1872) amounting to thirty-four per cent.

terize the class; and no wonder that from such a source spring the hopelessly incurable lunatics who crowd our pauper asylums, to the horror of rate-payers, and the surprise of those who cannot understand why the natives of Madagascar, though numbering about 5,000,000, do not require a single lunatic asylum. We may add that they do not destroy the few insane and idiots which they have.

It is constantly forgotten that while there is nothing better than true civilization, there is something worse than the condition of certain savages, and that almost anything is better than that stratum of civilized society which is squalid, and drunken, and sensual; cursed with whatever of evil the ingenuity of civilized man has invented, but not blessed with the counteracting advantages of civilization. The conclusion, so far from damping the efforts of progress and modern developments of science, should stimulate us to improve the moral and physical condition of this class, and so lessen the dangers to mental disorder among them. The belief that savages are free from some of the insanity-producing causes prevalent in modern civilized England, is quite consistent with the position taken in this article, that education, ample mental occupation, knowledge, and the regularly trained exercise of the faculties, exert a highly-beneficial influence upon the mind, and thus fortify it against the action of some of the causes of insanity.

The relative liability of manufacturing and agricultural districts to mental disease has excited much discussion. This has partly arisen from the assumption that the latter may be taken as the representatives of savages. As we have shown this to be false, the comparison between these two districts does not, from this point of view, possess any value. On other grounds, however, it would be very interesting to determine whether urban or rural lunacy is most rife. Here, however, the worthlessness of mere statistics is singularly evidenced, and the difficulty of actually balancing the weight of various qualifying circumstances becomes more and more apparent. An agricultural county may be found here and there with less lunacy than a manufacturing county, but if a group of counties be taken in which the manufacturing element is greatly beyond the average, and another group in which the agricultural element greatly preponderates, we find one lunatic to 463 of the county population in the former, and one to 388 in the latter, showing an *accumulation* of more insane paupers in the agricultural districts. But it is very possible that, if we knew how many *become* insane, the result would be very different indeed. This, in fact, has been found to be the case in Scotland, where the Lunacy Commissioners have taken great pains to arrive at the real truth. In a recent report it is shown that while three Highland counties have, in proportion to the population, a decidedly heavier persistent burden of pauper lunacy than two manufacturing counties which are chosen for comparison, the number of lunatics re-

ceiving relief—that is, actually coming under treatment—is proportionally larger in the latter than in the former. In other words, the proportion of fresh cases of pauper lunacy appearing on the poor-roll is higher in urban than rural districts. The commissioners refer this result partly to the greater prevalence of the active and transitory forms of mental disorder—cases which before long are discharged—and partly to the greater facility of obtaining accommodation in an asylum free of charge in a city, from its being at hand; and the greater wealth of the urban districts offering no obstacle to admission. They attribute the above-mentioned persistent rural lunacy chiefly to the constant migration of the strong from the rural to the urban districts; the necessary exodus of the physically and mentally healthy leaving behind an altogether disproportionate number of congenital idiots, imbeciles, and chronic insane, in the agricultural counties. Hence, returning to England, it is quite clear that the mere ratio of accumulated pauper lunacy to the county population, which is constantly relied upon, proves little or nothing as to the relative liability to insanity of the agricultural and manufacturing districts. One conclusion only can be safely drawn from such figures, until minute investigations have been made into the circumstances attending rural and urban lunacy in England as has been done in Scotland—namely, that while theory is apt to say that a country life, passed, as it seems to be supposed, in pastoral simplicity, will not admit of the entrance of madness into the happy valley, fact says that, whatever may be the ultimate verdict as to the relative proportion of urban and rural lunacy, a large amount of insanity and idiocy does exist in the country districts, and that the dull swain, with clouted shoon, but too frequently finds his way into the asylum.

A glance at the annual reports of our lunatic asylums reveals the main occupations of the inmates and the apparent causes of their attacks. In a county asylum like Wilts the great majority of patients are farm-laborers, with their wives and daughters; and next in order, domestic servants and weavers. The number of farmers, or members of their families, is small. The character of the occupations in the population of an asylum like that for the borough of Birmingham of course differs. Here we find mechanics and artisans heading the lists, with their wives. Those engaged in domestic occupation form a large number. Shopkeepers and clerks come next in order. In both asylums are to be found a few governesses and teachers. Innkeepers, themselves the cause of so much insane misery in others, figure sparingly in these tables.

Among the causes, intemperance unmistakably takes the lead. This is one of those facts which, amid much that is open to difference of opinion, would seem to admit of no reasonable doubt. Secondly follows domestic trouble, and thirdly poverty. At the Birmingham Asylum, out of 470 admissions in three years, eleven cases were at-

tributed to "over-application"—a proportion much lower than that observed in private asylums.

Recently, Mr. Whitcombe, assistant medical officer at the Birmingham Borough Asylum, has done good service by publishing the fact that, during the last twenty-five years, out of 3,800 pauper patients admitted into that asylum, 524, or fourteen per cent., had their malady induced by drink, and that the total expenditure thus caused by intemperance amounted, in maintenance and cost of building, etc., to no less than £50,373 during that period.

Some years ago we calculated the percentage of cases caused by intemperance in the asylums of England, and found it to be about twelve. This proportion would be immensely increased were we to add those in which domestic misery and pecuniary losses owed their origin to this vice. Although rate-payers grumble about the building of large lunatic asylums, it is amazing how meekly they bear with the great cause of their burden, and how suicidally they resent any attempt made to reduce by legislation the area of this wide-spread and costly mischief.

It is worthy of note that drink produces much less insanity in Warwickshire outside Birmingham than in Birmingham itself.

In connection with this aspect of the question, an interesting fact, recorded by Dr. Yellowlees, when superintendent of the Glamorgan County Asylum, may be mentioned: that during a "strike" of nine months the male admissions fell to half their former number, the female admissions being almost unaffected. "The decrease is doubtlessly mainly due to the fact that there is no money to spend in drink and debauchery." High wages, however, would be infinitely better than strikes, if the money were spent in good food, house-rent, and clothing.

The diet of the children of factory-operatives in Lancashire points to one source of mental degeneration among that class. Dr. Fergusson, of Bolton, gave important evidence not long ago which indicated the main cause of their debility and stunted development, whether or not they are worse now than they were. He does not consider that factory-labor in itself operates prejudicially, and reports the mills to be more healthy to work in now than they were in years past. The prime cause producing the bad physical condition of the factory-population is, in his opinion, the intemperate habits of the factory-workers. By free indulgence in stimulants and in smoking, the parents debilitate their own constitutions, and transmit feeble ones to their children. Instead of rearing them on milk after they are weaned, they give them tea or coffee in a morning, and in too many instances they feed them upon tea three times a day. In short, they get very little milk.

Mr. Redgrave, the Senior Inspector of Factories, does not consider that this miserable state of things has increased—we hope not—but

he admits that more women are employed in the mills than formerly, and that this is most disastrous to the training of children. Some curious figures have been published, showing the weight of children at various years of age in the factory and agricultural districts, the comparison being greatly in favor of the latter.

Another cause of deterioration mentioned is that at least one-half of the boys in the mills from twelve to twenty years of age either smoke or chew tobacco, or do both—a habit most prejudicial to the healthy development of the nervous system. It was recently observed by Mr. Mundella that the lad who began at eight years of age in a mine without education, and who was associated with men whose whole ambition was a gallon of beer and a bull-dog, was not likely to grow up to be a Christian and a gentleman. We may add he would be very likely to end his days either in a prison or in a pauper asylum. It is observed in a recent report of the Royal Edinburgh Asylum that "such coal and iron mining counties as Durham and Glamorgan produce, in twice the proportion we do, the most marked and fatal of all the brain-diseases caused by excesses." It may be stated that the relation between crime and insanity, especially weak-mindedness, is one of the most intimate character, both in regard to the people who commit criminal acts and their descendants. Our examination of the mental condition of convicts, and of their physiognomy and cerebral development, has long convinced us that a large number of this class are mentally deficient: sometimes from birth; at other times their mental development being arrested by their wretched bringing up. From the reports of the English convict-prisons generally, it appears that one in every twenty-five of the males is of weak mind, insane, or epileptic, without including those sufficiently insane to be removed to an asylum. The resident surgeon to the general prison of Scotland at Perth (Mr. Thompson) gives a proportion of twelve per cent., founded upon a prison population of 6,000 prisoners.

Having referred to the bearing of the habits of one large portion of the population upon the manufacture of insanity, we pass on to the consideration of the relation between higher grades of modern society and mental disorder. It has been observed in institutions into which private and pauper patients are admitted, that the moral or psychical causes of lunacy are more frequently the occasion of the attack with the former than the latter class. This is not always accounted for—as might have been expected—by there having been less drink-produced insanity among the well-to-do patients; for in the Royal Edinburgh Asylum, where this disparity strongly comes out, there is even a higher percentage of insanity from this cause among the private than the pauper lunatics. The history of the daily mode of life of many members of the Stock Exchange would reveal, in the matter of diet, an amount of alcoholic imbibition in the form of morning "nips," wine at luncheon, and at dinner, difficult to realize by many

of less porous constitutions, and easily explaining the disastrous results which in many instances follow, sooner or later, as respects disturbances of the nervous system, in one form or other. In fact, by the time dinner is due, the stomach is in despair, and its owner finds it necessary to goad a lost appetite by strong pickles and spirits, ending with black coffee and some liqueur. When either dyspepsia or over-business work is set down as the cause of the insanity of such individuals, it should be considered what influence the amount of alcohol imbibed has exerted upon the final catastrophe as well as the assigned cause. But whatever may be the relative amount of insanity produced among the affluent and the poor, of this there can be no doubt, that certain mental causes of lunacy, as over-study and business worry, produce more insanity among the upper than the lower classes. We have examined the statistics of six asylums in England for private patients only, and have found this to be the case. At one such institution, Ticehurst, Sussex, we find, from statistics kindly furnished us by Dr. Newington, that out of 266 admissions 29 were referred to over-study, and 18 to over-business work. Only 28 were referred to intemperance. Allowing a liberal margin for the tendency of friends to refer the disease to the former rather than the latter class, the figures remain striking, as pointing to the influence of so-called overwork. We say "so-called" because there is an apparent and fictitious as well as a real overwork. Both, however, may terminate in nervous disorder. Overwork is often confounded with the opposite condition—want of occupation. Civilization and mental strain are regarded by many as identical, and in consequence much confusion is caused in the discussion of the present question. It is forgotten that an idle life, leading to hysteria and to actual insanity, is much more likely to be the product of civilization than of savagery or barbarism. This is quite consistent with the other truth, that without civilization we do not see evolved a certain high pressure, also injurious to mental health. A London physician, Dr. Wilks, when speaking of a common class of cases, young women without either useful occupation or amusements, in whom the moral nature becomes perverted, in addition to the derangement of the bodily health, observes that the mother's sympathies too often only foster her daughter's morbid proclivities, by insisting on her delicacy and the necessity of various artificial methods for her restoration. It is obvious that such a case as this is the very child of a highly-organized society, that is, of a high state of civilization, and yet that such a young lady is not the victim of high pressure or mental strain in her own person, although it is certainly possible that she may inherit a susceptible brain from an overworked parent. However, the remedy is work, not rest; occupation, not idleness. We certainly do not want to make her more refined or artificial, but more natural, and to occupy herself with some really useful work. A luxurious, idle life is

her curse. That insanity itself, as well as mere hysteria, is developed by such a mode of existence, we fully believe. The mind, although not uneducated, deteriorates for want of either healthy intellectual excitement, the occupation of business, or the necessary duties of a family. Life must have an aim, although to achieve it there ought not to be prolonged worry.

In the same way there is the lady instanced who eats no breakfast, takes a glass of sherry at eleven o'clock, and drinks tea all the afternoon, and who, "when night arrives, has been ready to engage in any performance to which she may have been invited." Clearly she is the product of a highly-artificial mode of life, found in the midst of modern civilization. She is certainly not suffering from mental strain; at the same time she is the outcome of the progress from barbarism and the hardy forms of early national life to our present complex social condition. We have particularly inquired into cases coming under our own observation in regard to the alleged influence of overwork, and have found it a most difficult thing to distinguish between it and other maleficent agents which, on close observation, were often found to be associated with it. We do not now refer to the circumstances which almost always attach themselves to mental fatigue, as sleeplessness, but to those which have no necessary relation to them, as vice. Here we have felt bound to attribute the attack to both causes, certainly as much to the latter as the former. In some cases, on the other hand, we could not doubt that long-continued severe mental labor was the efficient cause of derangement. In a large proportion of other cases we satisfied ourselves that overwork meant not only mental strain, but the anxiety and harass which arose out of the work in which a student or literary man was engaged. The overwork connected with business, also largely associated with anxiety, proved a very tangible factor of insanity. Indeed it is always sure to be a more tangible factor of mental disease than overwork from study, because of the much greater liability to its invasion during the business period of brain-life than the study period. At Bedlam Hospital, Dr. Savage finds that there are many cases in which overwork causes a breakdown, "especially if associated with worry and money troubles." Among the women, the cases are few in number. In one, where there was probably hereditary tendency, an examination, followed in two days by an attack of insanity, may be regarded as the exciting cause. Monotonous work long continued would seem to exert an unfavorable influence on the mind. Letter-sorting, shorthand writing, and continuous railway-traveling, are instanced. If diversified, hard work is much less likely to prove injurious. During a year and a half twenty men and eight women were admitted whose attacks were attributed to overwork. The employments of architect, surveyor, accountant, schoolmaster, policeman, and boot-maker, were here represented. Seven were clerks, two of whom were law-writers;

two were students, one being "an Oxford man who had exhausted himself in getting a double first, and the other a medical student preparing for his second college." Of the women, five were teachers, one a school-girl, and two dressmakers. Three of the teachers were in elementary schools, one a governess and the other a teacher of music and languages. If overwork alone did not, strictly speaking, cause the mental breakdown, still the concomitants must be blamed for these melancholy results.

A late medical officer to Rugby School (Dr. Farquharson), in defending that institution from a charge of injury in the direction of which we now speak, considers that instances of mental strain are more common at the universities, "for not only are the young men at a more sensitive period of life, but they naturally feel that to many of them this is the great opportunity—the great crisis of their existence—and that their success or failure will now effectually make or mar their career. Here the element of anxiety comes into play, sleep is disturbed, exercise neglected, digestion suffers, and the inevitable result follows of total collapse, from which recovery is slow and perhaps never complete."—(*Lancet*, January 1, 1876.) He thinks he has seen an increase of headaches and nervous complaints among poor children since compulsory attendance at board schools was adopted, and records a warning against too suddenly forcing the minds of wretchedly-feeble, ill-fed and ill-housed children, and against attempts to make bricks too rapidly out of the straw which is placed in our hands.

The psychological mischief done by excessive cramming both in some schools and at home is sufficiently serious to show that the reckless course pursued in many instances ought to be loudly protested against. As we write, four cases come to our knowledge of girls seriously injured by this folly and unintentional wickedness. In one, the brain is utterly unable to bear the burden put upon it, and the pupil is removed from school in a highly-excitable state; in another, epileptic fits have followed the host of subjects pressed upon the scholar; in the third, the symptoms of brain-fog have become so obvious that the amount of schooling has been greatly reduced; and, in a fourth, fits have been induced and complete prostration of brain has followed. These cases are merely illustrations of a class, coming to hand in one day, familiar to most physicians. The enormous number of subjects which are forced into the curriculum of some schools and are required by some professional examinations, confuse and distract the mind, and by lowering its healthy tone often unfit it for the world. While insanity may not directly result from this stuffing, and very likely will not, exciting causes of mental disorder occurring in later life may upset a brain which, had it been subjected to more moderate pressure, would have escaped unscathed. Training in its highest sense is forgotten in the multiplicity of subjects, originality is stunted

and individual thirst for knowledge overlaid by a crowd of novel theories based upon yet unproved statements. Mr. Brudenell Carter, in his "Influence of Education and training in preventing Diseases of the Nervous System," speaks of a large public school in London, from which boys of ten to twelve years of age carry home tasks which would occupy them till near midnight, and of which the rules and laws of study are so arranged as to preclude the possibility of sufficient recreation. The teacher in a high-school says that the host of subjects on which parents insist upon instruction being given to their children is simply preposterous, and disastrous alike to health and to real steady progress in necessary branches of knowledge. The other day we met an examiner in the street with a roll of papers consisting of answers to questions. He deplored the fashion of the day; the number of subjects crammed within a few years of growing life; the character of the questions which were frequently asked; and the requiring a student to master, at the peril of being rejected, scientific theories, and crude speculations, which they would have to unlearn in a year or two. He sincerely pitied the unfortunate students. During the last year or two the public have been startled by the suicides which have occurred on the part of young men preparing for examination at the University of London; and the press has spoken out strongly on the subject. Notwithstanding this, the authorities appear to be disposed to increase instead of diminish the stringency of some of the examinations. The *Lancet* has recently protested against this course in regard to the preliminary scientific M. B. of the London University, and points out that the average of candidates who fail at this examination is already about forty per cent., and that these include many of the best students. This further raising of the standard will, it is maintained, make a serious addition to the labors of the industrious student who desires the M. D. degree. Whether this particular instance is or is not a fair example, we must say, judging from others, that it seems to be thought that the cubic capacity of the British skull undergoes an extraordinary increase every few years, and that therefore for our young students more subjects must be added to fill up the additional space.

The master of a private school informs us that he has proof of the ill effects of overwork in the fact of boys being withdrawn from the keen competition of a public-school career, which was proving injurious to their health, and sent to him, that they might in the less ambitious atmosphere of a private school pick up health and strength again. He refers to instances of boys who had been crammed and much pressed in order that they might enter a certain form or gain a desired exhibition, having reached the goal successfully, and then stagnated. He says that the too extensive curriculum now demanded ends in the impossibility of doing the work thoroughly and well. You must either force unduly or not advance as you

would wish to do; the former does injury, and the latter causes dissatisfaction.

Of mental stagnation among the poor we have already spoken; an analogous condition among the well-to-do classes, not to be confounded with that of the young lady already described as seen in the London physician's consulting-room, deserves a passing observation. Excessive activity and excessive dullness may lead to the same dire result. Hence both conditions must be recognized as factors in the causation of mental disease. We have said that the indirect action of the latter it more powerful than its direct action, but there are no doubt cases of insanity which arise from the directly injurious influence of intellectual inactivity. The intelligence is inert; the range of ideas extremely limited; the mind broods upon some trivial circumstance until it becomes exaggerated into a delusion; the mind feeds upon itself, and is hyper-sensitive and suspicious, or it may become absorbed in some morbid religious notions which at last exert a paramount influence and induce religious depression or exaltation. From the immediate surroundings of the individual, whether in connection with parental training or from ecclesiastical or theological influences, or perhaps a solitary condition of life, there may be a dangerously restricted area of psychical activity. Prejudices of various kinds hamper the free play of thought; the buoyancy of the man's nature is destroyed; its elasticity broken; its strength weakened; and it is in fine reduced to a state in which it is a prey to almost any assertion however monstrous, if placed before it with the solemn sanctions which, from education, habit, or predilection, it is accustomed to reverence. Fantastic scruples and religious delusions frequently spring up in this soil. Such persons have been saved from the evils of drunkenness and vice; they have also been sheltered from worry and excitement, yet, to the astonishment of many, they become the inmates of a lunatic asylum. They have in truth escaped the Scylla of dissipation or drink, only to be shipwrecked on the Charybdis of a dreary monotony of existence. On this barren rock not a very few doubtless perish, and if parents they transmit, to a posterity deserving our sincerest pity, mediocre brains or irritably susceptible and unstable nerve-tissue.

On the dangers arising from waves of religious excitement, it would be easy to dilate, but we shall content ourselves with remarking that, if they have been exaggerated by some, they have been improperly ignored or denied by others. They are real; and frightful is the responsibility of those who, by excited utterances and hideous caricatures of religion, upset the mental equilibrium of their auditors, whether men, women, or children.

One remarkable feature of modern life—spiritualism—has been said to produce an alarming amount of insanity, especially in America. It has been recently stated by an English writer that nearly 10,000

persons have gone insane on the subject, and are confined in asylums in the United States; but careful inquiry, made in consequence, has happily disproved the statement, and we learn that the amount of insanity produced from this cause is almost insignificant—much less than that caused by religious excitement.

Looking broadly at the facts which force themselves upon our attention, we may say that a study of the relation between modern life and insanity shows that it is of a many-sided and complex character; that the rich and the poor, from different causes, though certainly in one respect the same cause, labor under a large amount of *preventable* lunacy; that beer and gin, mal-nutrition, a dreary monotony of toil, muscular exhaustion, domestic distress, misery and anxiety, account largely, not only for the number of the poor who become insane in adult life, but who, from hereditary predisposition, are born weak-minded or actually idiotic; that among the middle classes, stress of business, excessive competition, failures, and, also in many cases, reckless and intemperate living, occasion the attack; while in the upper classes intemperance still works woe—and under this head must be comprised lady and gentlemen dipsomaniacs who are not confined in asylums; that while multiplicity of subjects of study in youth and excessive brain-work in after-life exert a certain amount of injurious influence, under-work, luxurious habits, undisciplined wills, desultory life, produce a crop of nervous disorders, terminating not unfrequently in insanity. In a state of civilization like ours, it must also happen that many children of extremely feeble mental as well as bodily constitutions will be reared who otherwise would have died. These either prove to be imbeciles, or they grow up only to fall a prey to the upsetting influence of the cares and anxieties of the world. A considerable number of insane persons have never been really whole-minded people; there has, it will be found on careful inquiry, been always something a little peculiar about them, and when their past life is interpreted by the attack which has rendered restraint necessary, it is seen that there had been a smouldering fire in the constitution for a lifetime, though now, for the first time, bursting forth into actual conflagration.

Lastly, modern society comprises a numerous class of persons, well-meaning, excitable, and morbidly sensitive. Some of these are always on the border-land between sanity and insanity, and their friends are sometimes tempted to wish that they would actually cross the line, and save them from constant harass. When they do, it is easier to make allowance for them and their vagaries.

Whatever uncertainty there may attach to some aspects of this inquiry, unquestionable conclusions have been drawn; and, if these only accord with results arrived at from other considerations, they are valuable as confirming them. Had there appeared to be among the poor and ignorant a striking immunity from attacks of insanity,

a strong argument would have been afforded, and would probably have been employed, against the extension of education at the present day to the working-classes. Nothing, however, in our facts or figures supports such an anti-progressive view; and, if the educated classes did not sin against their mental health in so many ways, they would doubtless compare more favorably than they do, in fact as well as in mere figures, with the uneducated poor. So again with regard to intemperance, and all that it involves, in spite of the difficulty of discriminating between the many factors which often go to make up the sum total of causes of an attack, we have no doubt of the large influence for mental evil exerted by drink—always admitting that where the constitution has no latent tendency to insanity, you may do almost what you like with it, in this or any other way, without causing this particular disease. A man will break down at his weak point, be it what it may.

Again, the lessons are taught of the importance, not of mere education, but a real training of the feelings; the evil of mental stagnation, not simply *per se*, but from the train of sensual degradation in one direction, and of gloomy fanaticism in the other, engendered, and the danger of dwelling too long and intently on agitating religious questions, especially when presented in narrow and exclusive forms, which drive people either to despair or to a perilous exaltation of the feelings. To true religious reformers, the physician best acquainted with the causation of mental disease will award his heartiest approval. Only as the high claims of duty, demanded from man by considerations of the dependence of his work in the world upon mental health, of what he owes to his fellow-men, and of what he owes to God, are fulfilled as well as acknowledged, will civilized man benefit by his civilization, as regards the prevention of insanity. Unpreventable lunacy will still exist, but a great saving will be effected for British rate-payers when that which is preventable shall have been reduced to a minimum by the widest extension of a thorough but not oppressive and too early commenced education, by the practical application of the ascertained truths of physiological and medical science, and by the influence of a Christianity, deep in proportion to its breadth, which shall really lay hold of life and conduct, and mould them in accordance with itself.—*Macmillan's Magazine.*

THE GROWTH OF THE STEAM-ENGINE.[1]

By Professor R. H. THURSTON,
of the Stevens Institute of Technology.

IV.

STEAM-NAVIGATION.

72. Among the most interesting of the applications of steam-power, to the political economist and to the historian, as well as to the engineer, is its use in ship-propulsion.

In the modern marine engine we find one of the most important adaptations of steam machinery and the greatest of all the triumphs of the mechanical engineer.

Although, as has been already stated in previous lectures, attempts had been made, before the beginning of the present century, to successfully effect this application of the power of steam, they did not succeed, in any instance, as commercial enterprises, until after that date.

Indeed, it is but a few years ago that the passage across the Atlantic was made by sailing-vessels almost exclusively, and that the dangers, the discomforts, and the irregularities of their trips were most serious.

Now, hardly a day passes that does not see several large and powerful steamers leaving the ports of New York and Liverpool to make the same voyages; and their passages are made with such regularity and safety that travelers can anticipate, with confidence, the time which will mark the termination of their voyage, predicting the day and almost the hour of their arrival, and can cross with safety and comparative comfort, even amid the storms of winter.

Yet, all that we to-day see of the extent and the efficiency of steam-navigation has been the work of the present century; and it may well excite both our wonder and our admiration.

73. The history of this development of the use of steam-power illustrates, more perfectly than any other, that process of the growth of this invention which has been already referred to. We can here trace it, step by step, from the earliest and rudest devices up to those most recent and most perfect designs, which represent the most successful existing types of the heat-engine—whether considered with reference to its design and construction, or as the highest application of known scientific principles—that have yet been found attainable in even the present advanced state of the mechanic arts.

74. This application of the force of steam was very possibly anti-

[1] An abstract of "A History of the Growth of the Steam-Engine," to be published by D. Appleton & Co.

cipated 800 years ago by Roger Bacon, that learned Franciscan monk who, in an age of ignorance and intellectual torpor, wrote:

"I will now mention some wonderful works of art and Nature, in which there is nothing of magic and which magic could not perform.

"Instruments may be made by which the largest ships, with only one man guiding them, will be carried with greater velocity than if they were full of sailors," etc.

For many years before even the first promising effort had been made, the minds of the more intelligent had been prepared to appreciate the invention when it should finally be brought forward, and were ready for even greater wonders than have yet been accomplished.

75. The earliest attempt to propel a vessel by steam is claimed, by Spanish authorities, as it has been stated, to have been made by Blasco de Garay in the harbor of Barcelona, Spain, in 1543.

The account seems somewhat apocryphal, and the experiment, if made, certainly led to no useful results.

76. In an anonymous English pamphlet, published in 1651,[1] which is supposed, by Stuart, to have been written by the Marquis of Worcester, an indefinite reference to what may probably have been the steam-engine is made, and it is there stated to be capable of successful application to propelling boats.

77. In 1690 Papin proposed to use his piston-engine to drive paddle-wheels to propel vessels; and in 1707 he applied the steam-engine, which he had proposed as a pumping-engine, to driving a model boat on the Fulda, at Cassel.

In this trial he probably used the arrangement of which a sketch

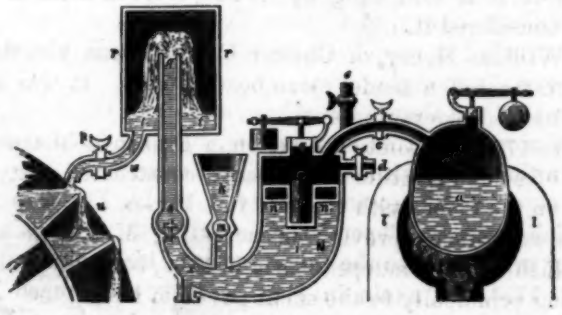


FIG. 44.—PAPIN'S MARINE ENGINE, 1707.

is here shown. His pumping-engine forced up water to turn a water-wheel, which, in turn, was made to drive the paddles, as in Fig. 44.

[1] "Inventions of Engines of Motion, recently brought to Perfection," London, 1651. A number of such treatises, vaguely hinting at new motors for propulsion of vessels, appeared during the sixteenth and seventeenth centuries.

An account of his experiment is to be found in manuscript in the correspondence between Leibnitz and Papin, preserved in the Royal Library at Hanover.

78. December 21, 1736, Jonathan Hulls took out an English patent for the use of a steam-engine for ship-propulsion, proposing to employ his steamboat in towing.

In 1737 he published a well-written pamphlet[1] describing this apparatus, an engraving of which is here shown in fac-simile.

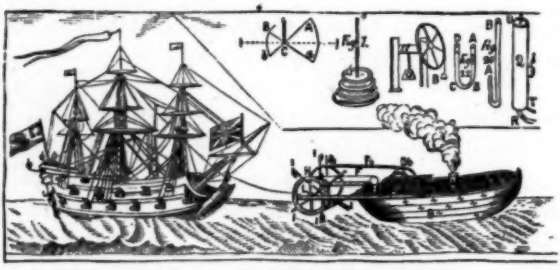


FIG. 45.—HULLS'S STEAM TOWBOAT, 1737.

He proposed using the Newcomen engine, fitted with a counterpoise weight, and a system of ropes and grooved wheels, which, by a peculiar ratchet-like action, gave a continuous rotary motion.

There is no positive evidence that Hulls ever put his scheme to the test of experiment, although tradition does say that he made a model, which he tried with such ill success as to prevent his further prosecution of the experiment. Doggerel rhymes are still extant which were, it is said, sung by his neighbors in derision of his *folly*, as they considered it.

79. William Henry, of Chester County, Pennsylvania, is said to have constructed a model steamboat in 1763. It was a failure, although not a discouraging one.

80. In 1774 the Comte d'Auxiron, a French nobleman, and a gentleman of some scientific attainments, constructed a steamboat, and tried it on the Seine, with the aid of M. Perier.

This experiment proving unsuccessful, M. Perier built another boat, which he tried independently in 1775, but was again unsuccessful, owing principally to the small power of his engine.

81. In 1778, and again in 1781 or 1782, the French Marquis de Jouffroy, who, in his later experiments, used quite a large vessel, succeeded in obtaining such good results as to encourage him to persevere, but, political disturbances driving him from his country, his labors terminated abruptly.

[1] "A Description and Draught of a Newly-invented Machine for carrying Vessels or Ships out of or into any Harbor, Port, or River, against Wind and Tide, and in a Calm," London, 1737.

82. About 1785 John Fitch and James Rumsey, two ingenious American mechanics, were engaged in experiments having in view the application of steam to navigation.

83. Rumsey's experiments began in 1774, and in 1786 he succeeded in driving a boat at the rate of four miles an hour against the current of the Potomac, at Shepardstown, Maryland.

Rumsey employed his engine to drive a great pump, which forced a stream of water aft, thus propelling the boat forward.

This same method has been recently tried again by the British Admiralty in the Water-witch, a gunboat of moderate size, using a centrifugal pump to set in motion the propelling stream, and with some other modifications which are decided improvements upon Rumsey's rude arrangements, but which have not done much more than did his toward the introduction of "hydraulic propulsion," as it is now called.

Rumsey died of apoplexy while explaining some of his schemes before a London society a short time later.

84. John Fitch was an unfortunate and eccentric, but very ingenious, Connecticut mechanic.

After roaming about until forty years of age, he finally settled on the banks of the Delaware, where he built his first steamboat.

In 1788 he obtained a patent for the application of steam to navigation.

His boat is shown in Fig. 46; it was sixty feet long and twenty

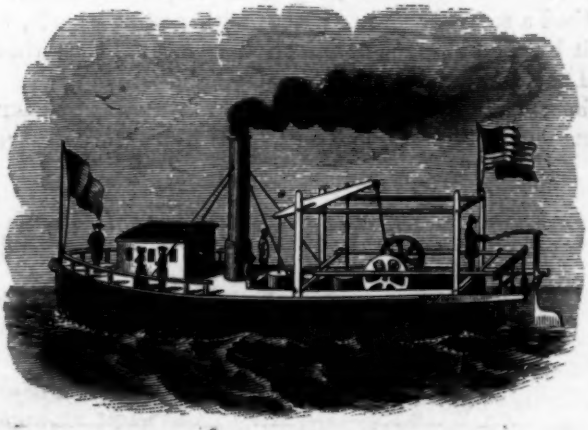


Fig. 46.—John Fitch, 1788.

feet wide. The propelling apparatus was a system of paddles, which were suspended by the upper ends of their shafts, and moved by a series of cranks, one to each, taking hold at the middle, and giving them almost exactly the motion which is imparted to his paddle by the Indian in his canoe.

Fig. 47 exhibits a sketch, reëngraved from a French work, which illustrates at once another of Fitch's steamboats and the Gallic artist's idea of the flora on the banks of the Delaware.

Fitch, while urging the importance and the advantages of his plan, confidently stated his belief that the ocean would soon be

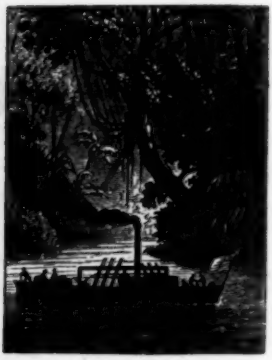


FIG. 47.—AN IDEAL SKETCH OF THE DELAWARE.

FIG. 48.—STEAMBOAT ON DALSWINTON LAKE, 1788.

crossed by steam-vessels, and that the navigation of the Mississippi would also become exclusively a steam-navigation.

Fitch's boat, when tried at Philadelphia, was found capable of making eight miles an hour. It was laid up in 1792.

85. In 1788 Patrick Miller, James Taylor, and William Symmington, attached a steam-engine to a boat with paddle-wheels, which had been built by the first-named, and tried it for the first time on Dalswinton Lake, in Dumfriesshire, Scotland.

This boat, having attained a speed of five miles an hour, another was constructed (Fig. 48), and was tried in 1789. This vessel was

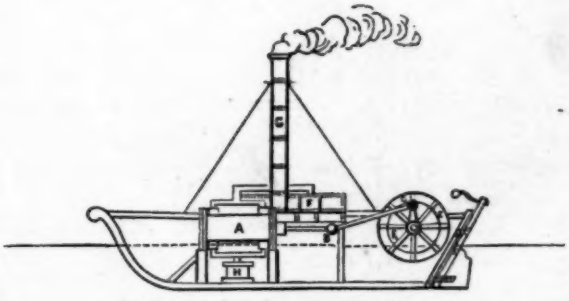


FIG. 49.—THE CHARLOTTE DUNDAS, 1801.

driven by an engine of twelve-horse power, and made seven miles an hour. This result, encouraging as it was, led to no further immediate action, the funds of the experimenters having failed.

86. In 1801, however, Symmington was employed by Lord Dundas to construct a steamboat, with the design of substituting steam for horse-power on canals.

After several trials, Symmington, whose experience, with Miller and Taylor, had been of much service in directing his experiments, completed a towboat, of which a sectional view is seen in Fig. 49, which he fitted with a stern-paddle wheel and a double-acting crank-engine of twenty-two inches diameter of cylinder and four feet stroke. This boat attained a speed of six miles an hour; but was laid aside, although perfectly successful, in consequence of a fear of injuring the banks of the canal by the waves produced by it.

Robert Fulton.

The Charlotte Dundas, as this boat was named, was so evidently a success that the Duke of Bridgewater ordered *eight* similar vessels for his canal; but his death, soon afterward, prevented the order being filled.

87. At this time, several American mechanics were also still working at this attractive problem.

In 1802–'3, Robert Fulton, with our other distinguished countryman, Mr. Joel Barlow, the patentee of the "Barlow boiler" (Fig. 50), in whose family he resided, and Chancellor Livingston, who had at that time taken up a temporary residence in Paris, commenced a small steamboat eighty-six feet long and of eight feet beam. The hull was altogether too slight to bear the weight of the machinery, and, when almost completed, the little craft literally broke in two, and sank at her moorings.

The wreck was promptly recovered and rebuilt, and in August, 1803, the trial-trip was made in presence of a large party of invited guests.

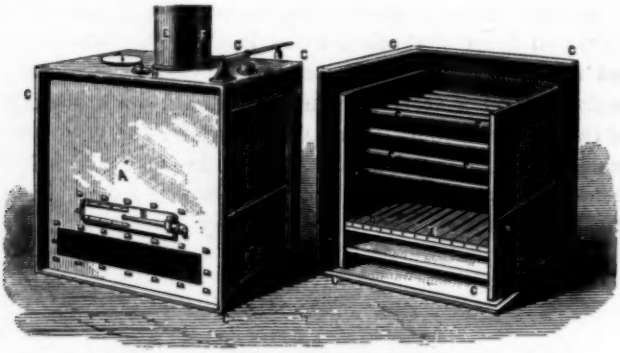


FIG. 50.—WATER-TUBE BOILER OF FULTON AND BARLOW, 1793.

88. The experiment was sufficiently successful to induce Fulton and Livingston to order an engine of Messrs. Boulton and Watt, directing it to be sent to America, where Livingston soon returned. In 1806 Fulton followed, reaching New York in December, and at once going to work on the vessel for which the English firm sent the engine, without being informed of its intended use.

In the spring of 1807 the Clermont (Fig. 51), as the new boat

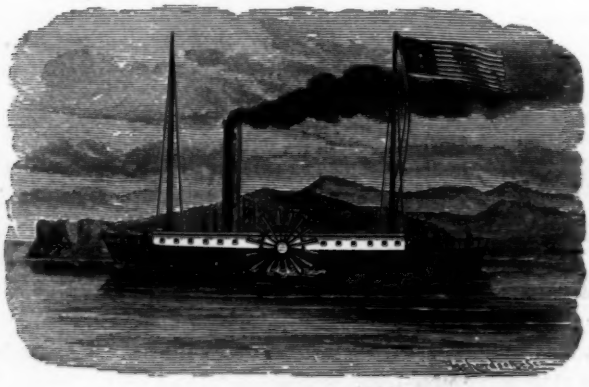


FIG. 51.—THE CLERMONT, 1807.

was christened, was launched from the ship-yard of Charles Brown, on the East River, New York.

In August, the machinery was on board, and in successful operation. The hull of this boat was one hundred and thirty-three feet long, eighteen feet beam, and seven feet in depth.

The boat soon afterward made a trip to Albany, making the dis-

tance of one hundred and fifty miles in thirty-two hours running time, and returning in thirty hours. The sails were not used on either occasion.

This was the first voyage of considerable length ever made by a steam-vessel, and the Clermont was soon after regularly employed as a passenger-boat between the two cities.

Fulton, though not to be classed with James Watt as an inventor, is entitled to the great honor of having been the first to make steam-navigation an every-day commercial success, and of having thus made the first application of the steam-engine to ship-propulsion which was not followed by the retirement of the experimenter from the field of his labors before success was permanently insured.

89. The engine of the Clermont (Fig. 52), was of rather pecu-

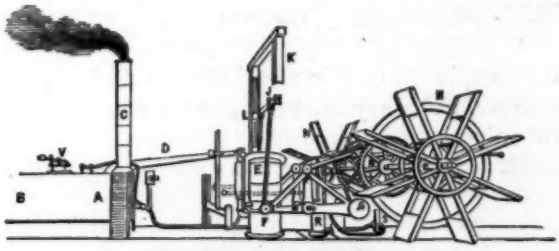


FIG. 52.—ENGINE OF THE CLERMONT, 1807.

liar form, the engine being coupled to the crank-shaft by a bell-crank, and the paddle-wheel shaft being separated from the crank-shaft, but connected with the latter by gearing. The cylinders were twenty-four inches in diameter and of four feet stroke. The paddle-wheels had buckets four feet long, with a dip of two feet.

An old drawing made by Fulton's own hand, showing this engine as it was improved in 1808, is in the relic-corner of the lecture-room of the author at the Stevens Institute of Technology.

The voyage of this steamer to Albany was attended with some ludicrous incidents, which found their counterparts whenever subsequently steamers were for the first time introduced.

90. Mr. Colden, the biographer of Fulton, says that she was described by persons who had seen her passing at night, "as a monster moving on the waters, defying wind and tide, and breathing flames and smoke."

This first steamboat used dry pine-wood for fuel, and the flame rose to a considerable distance above the smoke-pipe, and, when the fires were disturbed, mingled smoke and sparks rose high in the air.

"This uncommon light," says Colden, "first attracted the attention of the crews of other vessels. Notwithstanding the wind and tide were averse to its approach, they saw with astonishment that it was rapidly coming toward them, and, when it came so near that the

noise of the machinery and paddles was heard, the crews (if what was said in the newspapers of the time be true), in some instances, shrunk beneath their decks from the terrific sight, and left their vessels to go on shore; while others prostrated themselves, and besought Providence to protect them from the approach of the horrible monster which was marching on the tides, and lighting its path by the fires which it vomited."

91. Subsequently, Fulton built several steamers and ferry-boats, to ply about the waters of the States of New York and of Connecticut.

The Clermont was a boat of but 160 tons burden; the Car of Neptune, built in 1807, was 295 tons; the Paragon, in 1811, measured 331; the Richmond, 1813, 370 tons; and the Fulton, the first built in 1814–'15, measured 2,475 tons. The latter vessel, whose size was simply enormous for that time, was what was then considered an exceedingly formidable steam-battery, and was built for the United States Navy.

Before the completion of this vessel, Fulton died of disease resulting from exposure, February 24, 1815, and his death was mourned as a national calamity.

92. But Fulton had some active and enterprising rivals.

Oliver Evans.

Oliver Evans had, in 1801 or 1802, sent one of his engines, of about 150 horse-power, to New Orleans, for the purpose of using it to propel a vessel, owned by Messrs. McKeever and Valcourt, which was there awaiting it.

The engine was actually set up in the boat, but at a low stage of the river, and no trial could be made until the river should again rise, some months later. Having no funds to carry them through so long a period, Evans's agents were induced to remove the engine again, and to set it up in a saw-mill, where it created great astonishment by its extraordinary performance in sawing lumber.

THE MAGNETIC OBSERVATORY AT MADISON, WISCONSIN.

By E. W. DAVIS.

A VISITOR to the grounds of the State University at Madison, Wisconsin, might perhaps wonder what could be the use of three small chimneys to be seen standing out of the south side of the university hill. On being told that under the ground is one of the two magnetic observatories of this country, he may be curious to see more. If so, he will go on down some distance past the chimneys, and, turning into a moderately deep cut, will enter the observatory through a tunnel in the hill-side.

Having divested himself of whatever iron he may have about him —his keys, his knife, and even his watch—two doors are successively thrown open, and he is ushered into a low, vaulted chamber measuring seventeen feet square. The darkness, which would be absolute but for the faint gleams of light escaping through the close coverings of three lamps; the silence, broken only by the ticking of two clocks, or the tread upon the paved floor; the strange character of the instruments, which he begins dimly to see—all unite to create a feeling of oppression, as though one breathed the air of some sorcerer's den.

Though the visitor may be interested in what there is to be seen, yet, in the short time he is allowed to stay, he can get but an imperfect idea of it all. He will learn, it may be, the names of the several instruments, and gain a slight knowledge of the manner in which the observations are recorded. He will be told that the observatory was established at Madison in the autumn of 1876 by the United States Coast Survey; and also, perhaps, that the instruments employed were in use at Key West, Florida, and then at Washington, D. C., being moved from the latter place in order not to be so nearly upon the meridian of a magnetic observatory at Quebec, Canada. If desired, the person in charge will show him some of the traces, one of these being nothing more than the crooked path which a moving spot of light, reflected from a mirror attached to either of the magnets, has left upon sensitive paper.

In order to really profit by his visit, he should have gained, beforehand, some idea of what is to be observed and the manner of observing. This information I shall try to give the readers of this article; and then proceed with a description of the observatory and its equipments.

The force called terrestrial magnetism is subject to variations both in intensity and in direction. There are three ways in which a varying force of this kind may be measured:

1. It may be resolved into components acting along three axes, and the intensity of these components measured. I am not aware that this method has ever been applied to the measurement of terrestrial magnetism; probably, because one of the components would be so small as not without great difficulty to be directly measured.

2. We may measure its intensity along some fixed axis, and its angular variation of direction from that axis, in each of two planes intersecting the same. This method is frequently employed. The fixed axis taken is the intersection of the plane of the magnetic meridian and the plane of the horizon, and the angular variations from the axis are measured in these planes, the variation in the horizontal plane being called the "declination," and that in the plane of the magnetic meridian the "dip."

3. We may measure the intensity of its components along two axes and its angular variation in direction from the plane of those two axes. This last is the method in use at the observatory. The axes assumed are horizontal and vertical, and their plane is that of the magnetic meridian. Angular variations from this plane may be measured in any plane at right angles to it, as the plane of the horizon, and are, therefore, changes of declination.

The instruments used for making the measurements are the declinometer, the bi-filar magnetometer, and the balance magnetometer.

The declinometer consists, essentially, of a bar magnet so suspended as to turn freely in the horizontal plane. Changes in the position assumed by the bar show changes in declination.

The magnet of the bi-filar magnetometer likewise turns in the vertical plane; but, while the magnet of the declinometer is free to assume any position in that plane, the magnet of this instrument is pulled by a constant force into a position at right angles to the magnetic meridian.

The magnet of the balance-magnetometer, like that of the last two instruments, is in a position at right angles to the magnetic meridian; but, unlike either of the other two, it turns in the vertical plane.

The only effect of the horizontal force is to press the magnet against its bearings, and were the magnet suspended at its centre of gravity, the north-seeking pole would point directly downward in obedience to the vertical force. In reality, the magnet is so suspended as to assume a position approximately horizontal. The force of gravity remaining constant, the magnet will not change its posi-

tion, except with a variation in the intensity of the vertical component of terrestrial magnetism.

In making the observations, care must be taken that the temperature be kept as nearly constant as possible, a magnet losing about one ten-thousandth part of its power for each degree Fahrenheit of increase in temperature; also, that no magnetic bodies are present to influence the magnets; that the instruments be secured from all mechanical interference; and that all the adjustments be true.

Let us see how these requirements are met. The observatory has been built underground, and has double walls and roof, there being a space of two feet between the outside and inside walls. A differential thermometer placed within shows a daily variation in temperature of but 1° or 2° Fahr. In case of artificial heat being required, a brick stove has been built, with which it would be impossible to cause a sudden change in temperature.

The observatory has been placed without the influence of iron water or gas pipes, and in its construction and furnishing no iron has been employed, all metallic supports, mountings, etc., being of brass, copper, or zinc. The reservoirs of the lamps used have to be taken outside to be filled, since to bring a so-called *tin* oil-can within the observatory would seriously disturb the instrument. As before mentioned, visitors to the observatory leave outside whatever of iron they may have about them. An abnormal variation in the movements of the magnets at the Key West Observatory is thought to have been caused by the landing of some heavy guns in the vicinity, and their subsequent transportation past the observatory.

The mounting of the instruments upon heavy blocks of stone and their close incasement reduce the chance of mechanical interference to a minimum.

To still further guard against errors of observation, there are special adjustments in the several instruments.

The magnet of the declinometer is suspended by a skein of one hundred fibres of silk, the utmost pains being taken to reduce the torsion to a minimum. The length of skein is at least three feet, so that any residual torsion has the less effect. It seems impossible, however, to entirely get rid of this disturbing element. The records of the Key West observations show that the torsion of the suspension skein changed rapidly during the first five months after the suspension of the magnet, and did not become constant even after six years.

As variations in temperature do not affect the direction of the line of action of the magnetic force, no temperature adjustment is required for the declinometer.

The magnet of the bi-filar magnetometer is rigidly connected with a small glass rod of the same length as the magnet. Over the ends of this rod slip two zinc tubes, of such length as to reach within about five millimetres of its centre. At the inner end of each tube is at-

tached one end of a suspension skein, that passes over a glass pulley three feet above the magnet. The diameter of the pulley is fourteen millimetres; it should, however, equal the distance between the ends of the suspension skein—ten millimetres. The present pulley is to be changed for one of that diameter.

The pulley is turned into such a position that the pull of the suspension skein brings the magnet approximately at right angles to the magnetic meridian. The magnet is in equilibrium under the action of three forces: gravity, the pull of the threads, and the horizontal component of the earth's magnetism. The first two forces being constant, the equilibrium is not destroyed save by a variation in the intensity of the third force. The changes in the direction of that force are never sufficiently great to appreciably alter the position of this magnet. The diameter of the pulley being greater than it should be, increases the leverage of the pull of the threads, and so lessens the ratio of the variation of the horizontal force to the sum of the opposing forces. The delicacy of the instrument is thus slightly impaired.

On each side of the point of suspension of the magnet is a place for a small weight. By weighting the magnet its angular position is slightly changed. A comparison of the effect thus produced with the changes due to variations in the horizontal force gives us a measure of that force. It is, in truth, weighing the magnetism.

Observe what takes place when the instrument is heated. Neither the glass pulley nor the glass rod would be sensibly affected. The magnet, however, would lose some of its power, and consequently be less strongly pulled by the horizontal force, which we wish to measure. To counterbalance this loss of magnetic power, the effect of one of the opposing forces must be diminished by an equal amount. This is effected by the zinc tubes, whose expansion brings the ends of the suspension skein nearer together, and thus lessens the pull of that skein.

I now come to the most delicate of all the instruments—the balance-magnetometer. Attached rigidly to the axis of this instrument, and at right angles to the same, is an axis, resting, through the interposition of agate knife-edges, upon an agate plate. By changing the position of small brass balls that screw upon vertical and horizontal arms of this axis, the centre of gravity of the instrument may be accurately adjusted to any desired position. None of these balls weigh over fifty grains, and the distance between two successive threads of the screw upon which they work is only the hundredth part of an inch; yet, if one of those for shifting the centre of gravity horizontally be turned through so much as the twentieth part of a revolution, thus advancing it the two-thousandth of an inch, the instrument will be so tilted as never to right itself. This extreme delicacy is attained by bringing the centre of gravity of the instrument close up under the axis of suspension. To prevent unnecessary wear of the agate

knife-edges, there is an arrangement for lifting the instrument off of its bearings, when not in use.

The balance-magnetometer requires a delicate temperature adjustment. For this purpose there is attached to the side of the magnet a small tube containing mercury. Such is the position of the tube that the shifting of the centre of gravity of the magnetometer, due to the expansion or contraction of the mercury, shall just balance the tendency of the north-seeking pole of the magnet to rise or fall with the temperature. Adjusting the tube to its proper position occupied Mr. Suess for five days.

The variations of these several instruments are recorded by photography, each instrument, with its recording apparatus, constituting a magnetograph. A cylinder, turned by clock-work, carries the sensitive paper upon which the record is to be made. A single cylinder, with its sensitive paper, suffices for both the declinometer and the bi-filar magnetometer, the cylinder turning between the two instruments and receiving the two records at its opposite ends. A second and vertical cylinder is required for the balance magnetometer. The record of all the instruments is made in the same way. The light from a German student-lamp, after passing through a narrow slit, is received upon a concave mirror carried by the magnet. The mirror throws a thread-like image of the slit upon two cylindrical lenses fixed in the case of the recording instrument. By these lenses the line of light is shortened to a dot, to be received by the sensitive paper.

Were the spot of light stationary, a straight line would be traced upon the sensitive paper, since, by the revolution of the cylinder, the paper would be carried directly forward from in under the light. But, by the movement of the magnet, the image of the slit is made to travel back and forth along the lenses and a more or less eccentric trace left upon the sensitive paper.

In order that the trace may not go beyond the limits of the paper, the magnet must be kept from swinging through more than a small arc. This is effected, in the bi-filar magnetometer, by the pull of the suspension skein acting against the magnetic force. In fact, owing to the too great size of the glass pulley, the magnet does not swing quite freely enough.

In the other two instruments a special arrangement is adopted. Surrounding the magnet and forming a closed circuit, is a rectangle of four flat copper bars. Any movement of the magnet gives rise to a current in the circuit, which tends to pull the magnet back again. Thus, if the north-seeking pole of the magnet in the declinometer be deflected toward the east, a current will be generated, running from south to north along the upper bar of the rectangle, and back along the lower bar. The current, in turn, acts upon the magnet, checking it in its swing toward the east, so that the paper can receive the entire trace.

In addition to the concave mirror, each magnet carries a plane mirror to receive the reflection of a scale attached to the back of a small telescope. The telescopes are mounted upon the stands of the recording instruments, and for convenience of observation are provided with diagonal eye-pieces. On looking into either telescope one sees its scale reflected in the plane mirror carried by one of the magnets. When the mirror turns with the swing of the magnet, the scale appears to the observer to traverse the mirror's face. At the beginning and again at the end of each trace a record is made of the division of the scale then covered by the cross-wires of the telescope. Knowing the times at which each trace was started and stopped, and the readings of the scale at those times, it is easy to divide off the paper into spaces corresponding to the hours of the day and into other spaces at right angles to these corresponding to divisions of the scale. An exact record is thus made of all magnetic variations.

Particular interest attaches to magnetic observations on account of the way in which the magnetic state of the earth seems to be influenced by the position of the sun, and to a slight degree by the position of the moon; also from the connection between auroral displays and magnetic variations, curves representing the frequency of either agreeing quite closely with curves representing the area of the sun covered by spots. It is well to remark that the curves representing magnetic variations and auroras lag about six months behind those representing the sun-spot variations. The sun-spot area seems in some way to depend upon the position of the planets. Not only is the earth's magnetism thus, seemingly at least, influenced by the sun-spots, but also some of the phenomena of the weather. These last are, of course, in general, masked by local disturbances; but, lately, a very remarkable agreement has been shown to exist between certain magnetic and barometric traces. Investigations into the causes of magnetic variations and the laws under which these variations occur are made by officers of the United States Coast Survey; and to the head-quarters of this survey, at Washington, are forwarded, each month, the traces obtained at Madison.

THE CHEMISTRY OF FRUIT-RIPENING.[1]

By ALBERT B. PRESCOTT,
PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF MICHIGAN.

TO form the seed seems to be the chief end of the plant. When in the vigor of its own maturity, and when receiving the sun's strongest rays and the earth's richest nourishment, the plant gathers

[1] From the forthcoming "Transactions of the Michigan Pomological Society" for 1877; furnished by the author for THE POPULAR SCIENCE MONTHLY.

all its resources, and devotes them to the building of the seed. When done, the seed itself, the embryo, commonly possesses little substance and serves little use beyond its primary purpose, the reproduction of the plant. But in *the coatings and coverings of the seed* we find a large and abundant supply of substances, in variety and quantity the rarest and richest stock in the vegetable commonwealth. Indeed, the wrappings of seed-germs constitute the especial provision for the nourishment of the human race. The seeds enveloped with starch and albuminoids, as in the cereal grains, make up "the staff of life" for man. Seeds with oily coatings, including the nuts, present a good supply of fats for food. The seeds with succulent coverings, the fruits, yield a great number of sharply-defined substances, most of which claim the approval of man, and some of which require for their due application the best efforts of the human intellect. Without the grains, the fruits, and the nuts, man would be left to browse with the ox and prey with the wolf.

In this abundant material gathered around the seed-germs, chemistry has achieved more success than elsewhere in the organic world. It is well understood that chemists have no reason to boast of what they can do with the products of living cells. In an analysis of vegetable or animal products, there is always a percentage, and often a large percentage, of unknown matter. It might be named "chemist's dirt;" not "matter out of place," but simply "matter unknown." It has weight, it may have color and consistence, but it responds to no inquiries and yields to no suggestions. Like an open polar sea, it baffles and invites and baffles again. But, with all due reservation for unknown bodies, the condition of organic analysis gives good ground for encouragement. Especially in this material about the seed, the analyst finds numerous compounds of clearly definite chemical character, many of them capable of sure identification and exact separation, even when taken in complex mixtures. Working with some of these compounds, an insight into their chemical structure has been obtained; so that the chemist can bring together the materials and conditions for their production. In the products of the peach, at every autumn's ripening, certain chemical changes occur in the kernel under your hand—changes as well known to science and capable of as exact quantitative statement as the local changes of the planets in the solar system. Forty-four years ago, Liebig and his fellow-workers discovered certain links in those chemical changes, in the products of the almond family, and the discovery was an era in chemical science.

The chemistry of the covered seed is of interest not only for the quality of the compounds found in it, but, quite as much, for the *history* of these compounds, *the chemical changes of seed and fruit-ripening* in the plant. These changes differ in their general character from other changes of plant chemistry, coinciding more nearly with the

changes of animal chemistry. Taking for study the ripening of *seeds with succulent coverings*, the fruits—the proper subject of this article—we may undertake to compare fruit-ripening with vegetable nutrition on the one hand, and with animal nutrition on the other hand, as follows:

In Vegetable Nutrition.	In Fruit-Ripening.	In Animal Nutrition.
1. Oxygen is given to the air.	Oxygen is taken from the air.	Oxygen is taken from the air.
2. Carbonic acid is taken from the air.	Carbonic acid is given to the air.	Carbonic acid is given to the air.
3. The service of plant-green is required.	The service of plant-green is dismissed.	.....
4. Simple compounds are changed to those more complex.	Complex compounds are changed to those more simple.	Complex compounds are changed to those more simple.
5. The expended power of the sun is stored.	The stored-up power of the sun is expended.	The stored-up power of the sun is expended.
6. Heat is absorbed.	Heat is liberated.	Heat is liberated.
7. The changes represent reductions and syntheses, difficult to the chemist, and hindered by atmospheric conditions.	The changes represent combustions and dissociations, and are mostly favored by atmospheric conditions.	The changes represent combustions and dissociations, such as are favored by atmospheric conditions.
8. Opposed to fermentations, and to other changes classed under the term organic decomposition.	The changes include a great number of distinct fermentations, some of which are spontaneous in the air, or occur in cooking food.	Some of the changes are allied to fermentations, but are mostly not liable to occur without the living body.
9. The important compounds of the vegetable kingdom—cellulose, starch, sugar, and many acids and other products—are common to the fruit and other parts of the plant.		Only a few animal products are found in the vegetable kingdom.

Fruit-ripening, then, coincides with vegetable nutrition in acting with the same substances, and coincides with animal nutrition in moving in the same direction.

To inquire, now, somewhat in detail, into the more obvious of the changes which constitute fruit-ripening, we may examine the proportion and formation of the following five classes of Fruit-Products:

1. Sugars (starches).
2. Pectous substances and gums.
3. Acids, tannin, and other glucosides.
4. Ethers.
5. Alkaloids.

The analyses of fruits hitherto reported have mostly been made by European chemists. The fullest reports of ripe fruits, upon which I am in good part dependent, were made by Fresenius, from analyses under his direction, nearly twenty years ago, and represent the fruits of the Rhine district, obtained at Wiesbaden.

1. Sugars.—The prevailing sugar in fruits is *glucose* (*dextrose*),

often termed grape-sugar. It is the same compound that is largely manufactured from starch, and called starch-sugar. It is much less sweet than cane-sugar, and less abundantly soluble in water, having an oily or "mealy" taste. As made from starch, it is now much used in certain candies. When in the uncrystallizable form, *glucose* (*lævulose*) is the same as "fruit-sugar," the uncrystallizable product obtained to some extent in manufacturing cane-sugar, and which forms a part of the sirups of the market. Many of the fruits contain *cane-sugar* (which is the same as beet-sugar and maple-sugar), and certain rare varieties of sugar are found in some fruits.

Buignet decided that the apple, peach, plum, raspberry, orange, and pineapple, contain cane-sugar, with *glucose* (mostly as *lævulose*). The sugar of the grape, cherry, gooseberry, and fig, consists wholly of *glucose*.

The average proportion of sugars in ripe fruits is given, by Fresenius, as follows (the smallest percentages being placed first):

Peaches, 1.6 per cent. (not varying very widely).
Apricots, 1.8 per cent. (from 1.1 to 2.7).
Plums, round red, 2.1 per cent. (from 2.0 to 3.5).
Greengages, 3.1 per cent.
Raspberries, 4.0 per cent. (from 3.0 to 5.0).
Blackberries, 4.4 per cent.
Strawberries, 5.7 per cent. (from 3.2 to 7.6).
Currants, 6.1 per cent. (from 4.8 to 6.6).
Gooseberries, 7.1 per cent. (from 6.0 to 8.2).
Pears, red, 7.4 per cent.
Apples, 8.4 per cent. (from 5.9 to 10.4).
Cherries, 9.8 per cent. (from 8.5 to 13.1).
[Summer peaches, 11.6 per cent. Berard's analysis.]
Grapes, 14.9 per cent. (from 13 to 19).

It is seen from this list that the *sweetness* of fruit has but slight correspondence with its proportion of sugar. Currants were found to have more sugar than raspberries, blackberries, or strawberries, and over three times as much as the peaches examined by Fresenius. All analysts agree in the predominance of grapes for their quantity of sugar. The sweetness of fruit is probably favored less by large proportions of sugar than by three other conditions, namely: 1. Small proportions of acids; 2. Large proportions of pectous substances; 3. Presence of cane-sugar instead of grape-sugar.

The sugar of fruits is chiefly formed or deposited in them during their ripening. Berard found that the pulp of cherries, unripe, contained only 1.1 per cent. of sugar; ripe, 18.1 per cent.; gooseberries, unripe, 0.5 per cent.; ripe, 6.02 per cent. In 1862 Hilger determined the *sugar of grapes*, at ten periods during their growth and ripening, as follows (*Landw. Versuchsstat*, xvii., 245; *Journal of the Chemical Society*, xxviii., 281):

		Austrian.	Riesling.
1.	June 27th	1.37 per cent.	1.01 per cent.
2.	August 16th	1.33 " "	1.23 " "
3.	August 22d	2.18 " "	1.81 " "
4.	August 28th	4.25 " "	2.39 " "
5.	September 1st	2.53 " "	2.58 " "
6.	September 12th	4.49 " "	2.89 " "
7.	September 17th	5.33 " "	3.87 " "
8.	September 23d	7.71 " "	7.70 " "
9.	October 10th	9.90 " "	8.64 " "
10.	November 10th	9.90 " "	8.21 " "

Whether the *sugar of fruits is formed* within them, or introduced through the stem, and, if formed in the fruits, from what substance formed, are questions which have been investigated, but not wholly settled. It has been pretty generally held that *starch* in the unripe fruits is converted into sugar in the ripe fruits; the fruit acids inducing the change, as we know they have power to do. But starch is not found in the unripe stage of all fruits, and, in the cases where found, its quantity is sometimes too small to serve as the source of all the sugar of the ripened fruit. In the investigation of Hilger, above quoted, the immature fruit was at no time found by microscopic examination to contain starch. It appeared in the fruit-stalks in June; after August it almost wholly disappeared from the fruit-stalks, and was found only in the wood of the vines. Payen (*Comptes Rendus*, liii., 313) reported that he had demonstrated the presence of starch in unripe fruits and its conversion to sugar during ripening; but did not ascertain how much of the sugar of fruits is formed in this way.

It has been advanced that sugar is formed *from malic and other acids*, during ripening, either in the fruit or in the parts of the plant supplying juices to the fruit. Six molecules of malic acid and six molecules of tartaric acid, with nine molecules (eighteen atoms) of oxygen, would furnish the atoms for formation of four molecules of glucose, twelve molecules of water, and twenty-four molecules of carbonic anhydride. Mercadante (*Gazetta Chimica Italiana*, cxxv.; *Journal of the Chemical Society*, xxviii. [1875], 904) made a series of determinations of the malic acid and sugar in plums, commencing May 20th. The quantities of both acid and sugar increased in the fruit so long as it was green and emitting oxygen in the daylight; the branches which bore the fruit containing acid and pectous substances but no sugar. During the same time, the pectous and gummy substances in the green fruit had decreased from six per cent. of the pulp to three per cent. of the pulp. The investigator believed the sugar of the green fruit to have been chiefly formed, in the fruit, from the pectous and gummy substances, under contact of the acids. As soon as the fruit, losing green color, began to emit carbonic acid in the daylight, the acid in it began steadily to decrease as the sugar increased. The increase of sugar at expense of the acid in the pulp of plums is shown as follows:

	Sugar.	Malic Acid.
June 20th	16.52	2.76 (per cent. in pulp).
June 24th	16.64	2.46 " "
June 30th	16.78	2.16 " "
July 4th	17.05	1.57 " "
July 12th	17.38	0.82 " "

The green plums contain *tannin*, which commenced to diminish as soon as the fruit began to emit carbonic acid in the daylight, wholly disappearing by June 20th, the date at which the malic acid began to diminish. It is well known to every one that many green fruits are very astringent, and that their tannin decreases and sometimes disappears during ripening. Also, it is a familiar fact in the chemistry of tannin that it readily undergoes changes producing sugar. This, then, is the source of a portion of the sugar of many fruits. The formation of sugar from tannin will be discussed under the head of the glucosides of fruits.

Several chemists have reported the presence of sugar-producing substances peculiar to fruits. Buignet describes a fruit constituent, astringent like tannin, and combining with iodine like starch, and serving as the source of sugar.

The proportion of *cane-sugar*, in most fruits, is generally believed to diminish by transformation into *glucose*, as fruits become fully ripe or overripe. But Berthelot and Buignet (*Comptes Rendus*, li., 1094) found that, in oranges, the proportion of cane-sugar increased during ripening, the quantity of *glucose* remaining unchanged.

The *increase of weight* of fruits, during ripening, is no doubt largely owing to deposition of sugar. Berard found that 100 parts of unripe summer peaches yielded 179 parts of ripe fruit, and 100 parts of unripe apricots increased in ripening to 200 parts.

The maturity of fruit is the period of its maximum quantity of sugar. Sooner or later, the quantity of *sugar begins to diminish*, and then the fruit is overripe. It is safe to say that the sugar often begins to decompose during the life of the fruit; that is to say, fruit becomes overripe during its life. It would be difficult, however, to fix on the termination of the life of fruit. We certainly cannot say that life ceases when the circulation with the plant is cut off; and we cannot say that life continues in the sarcocarp until it is wholly disintegrated. Now it is within the limits of our subject to inquire *by what changes the sugar begins to disappear.*

In general terms, sugar suffers *oxidation* in ripe fruits, small portions being oxidized away even during the production of larger portions, and before perfect maturity. We do not know what fruit constituents, if any, result in this oxidation. The *final* products of oxidation, carbonic acid and water, are exhaled during ripening, and with greater rapidity after maturity has been passed.

It seems to be established that sugar in fruits is liable to traces of

the alcoholic *fermentation*, even before maturity is passed. H. Gutzeit (Zeitscher Oest. Ap. Ver., 1875, p. 337; Pro. Am. Phar. Asso., 1876, p. 287) reports finding alcohol, or other simple compound of ethyl, in the fruits of a number of plants. Some of the fruits were not quite ripe, and none were overripe. De Luca (*Comptes Rendus*, lxxxiii., 512; *Jour. Chem. Soc.*, 1876, ii., 649) reports obtaining products of the alcoholic and acetic fermentations from the fresh fruits, leaves, and flowers, of several plants. In all these cases the quantities of alcohol obtained were very minute. The investigator first above named found methyl-alcohol, in some cases, with the ethyl-alcohol. Pasteur states that the germs which excite alcoholic fermentation are very abundant on the bunches of ripe grapes, where very rare in the atmosphere. Also, that the fermentive germs are found on ripe strawberries, cherries, and currants, but not on the same fruits unripe. The formation of methyl-alcohol, above referred to, is closely allied to the formation of methyl-salicylate or wintergreen-oil. A number of the essential or volatile oils, with which plants and fruits are perfumed and flavored, contain alcohol radicals in union as compound ethers. It is probable, from every point of view, that the slight occurrence of the vinous fermentation in fruits belongs to an important class of chemical formations, by means of which a multitude of odor-giving substances are scattered throughout vegetation. We shall inquire more carefully into the fruit-flavor compounds and their formation further on.

2. The Pectous Substances.—These are, in general terms, the constituents of plant-jelly. As vegetable products, they correspond to the varieties of gelatine obtained from animal tissues. Unlike gelatine, however, they are non-nitrogenous. They are found in the soft parts of plants generally, as in the tuber of the potato and the root of the carrot; but it is in fruits that they have most importance for edible value. The immediate origin of the pectous substances is pretty well known, being due to a specific fermentation, a prominent feature in fruit-ripening. The material from which all the pectous substances proceed is the fermentable body called *pectose*, an insoluble, tasteless substance, found abundantly in unripe fruits, also to some extent in immature roots and tubers, and having no more value for food than cellulose. Now, there is formed along with this substance a "ferment," as it is called, a body which by contact induces a specific fermentation—a definite chemical change. Pectase is the name of the ferment. Just as, in the germinating seed, starch, by contact with diastase, suffers fermentation with production of sugar, and as, in bruised and wetted mustard-seeds, sinigrin, by contact with myrosin, splits up into pungent oil of mustard and sugar, etc., so the crude pectose of green fruits, by contact of their pectase at the time of ripening, changes to the edible plant-jellies or pectous substances. Long boiling with water alone effects the same change.

Why this fermentation occurs just at the ripening-time, and not earlier or later, we do not precisely know. It may be that the pectose has just then become capable of fermentation, or the pectase then acquires potency for its office, or then, and not before, are other conditions of the change established. We know only that the fermentation gives us the before-mentioned pectous substances, which, moreover, succeed each other, during ripening, by repeated changes. It must be confessed that these products have been but imperfectly defined, but as a class their chief properties are known. They are given by chemists as follows (distinctions having value only in analysis being omitted):

Pectine: readily soluble in hot or cold water, gelatinizing when concentrated, and more perfectly by addition of sugar; changed by very long boiling to parapectine.

Pectic acid: gelatinous, insoluable in cold water, and but slightly soluble in hot water; hardened in jelly by solution of sugar, slowly changed by boiling to parapeptic acid, and afterward to metapeptic acid. Pectine and pectic acid result from long boiling of the crude *pectose.*

Parapectine: soluble in water, capable of gelatinizing slightly, changed by boiling to metapectine.

Parapeptic acid: soluble in water, the solution changing into one of metapeptic acid. Not gelatinous.

Metapectine: soluble in water, not gelatinous. (Found in overripe fruits.)

Metapectic acid: soluble in water, incapable of gelatinizing. (Found in overripe fruits; produced by fermentation in overripening from all the other pectous substances. Also produced, from most of the other pectous substances, by long boiling, much more readily if acids are present.)

Alkalies change pectine and parapectine and metapectine to salts of pectic acid.

The properties of the separated pectous compounds represent certain well-known characteristics of fruits, as these are found in *cooking.* Moist heat, as in any mode of cooking, produces upon these substances the chief results of ripening, and, if continued long enough, the results of overripening. *Unripe fruits* are made more edible and wholesome by cooking, owing to its artificial (imperfect) ripening of pectose. *Fruit-jellies* owe their substance to pectic acid, pectine, and slightly to parapectine, the products of early maturity, with the coöperation of sugar. For jellies, it is well known, the use of overripe fruits must be avoided, and too long boiling in the preparation must be avoided. If the fruit be underripe, the juice should be boiled much longer than if the fruit be fully ripe, and if the fruit be overripe, boiling should be maintained no longer than necessary to clarify, and standing in hot solution should be avoided. Grapes bear full ripening for jellies.

The following statements of the *quantities of pectous substances and of pectose* are compiled from the reports of Fresenius. It should

be mentioned that Fresenius found widely-different quantities in the different varieties of the same fruit, and the average here drawn from the varieties of each fruit would greatly vary from an average obtained from other varieties of the same. The percentage in the fresh fruit is first given, and then percentage of solids, or strictly dry fruit, as obtained by calculation from the percentage of water:

	Pectous Substances (soluble).		Pectose (insoluble).	
	Of Fresh Fr't.	Of Solids.	Fresh Fruit.	Solids.
	Per cent.	Per cent.	Per cent.	Per cent.
Peaches—mean of two varieties.....	8.45	42.25	0.85	4.25
Apples—mean of four varieties.....	5.85	34.41	1.23	6.59
Pears—mean of two varieties.....	3.84	22.58	0.97	5.70
Raspberries—mean of three varieties..	1.42	10.14	0.24	1.71
Gooseberries—mean of six varieties....	1.17	8.36	0.65	4.64
Cherries—mean of three varieties.....	1.59	7.23	0.78	3.54
Grapes—mean of two varieties.....	0.36	2.00	0.84	4.66
Currants—mean of six varieties.....	0.17	1.13	0.84	5.66
Strawberries—mean of three varieties..	0.10	0.79	0.50	3.85

As *food-materials*, the pectous substances seem to be wellnigh indispensable to the health of man. They are not very nutritious; it is not known that they are fully digested into material which can be appropriated; and, being non-nitrogenous, they could scarcely yield tissue-building matter. What service they perform is not clearly understood. They may supply liquids important in digestion or assimilation. We obtain them in acidulous fruits, and in starchy tubers, and it is not clear how much of the value of each of these sorts of food is due to their pectous constituents; but, when all food containing pectine is cut off, the scurvy is liable to ensue, and then any food supplying pectine will serve as a remedy. At the same time it is found that pectous food is needed only in small quantities; large proportions proving not only innutritious but injurious, causing derangements of digestion and excretion.

3. Acids.—The principal fruit-acids, not astringent, are the following, given in the order of their importance:

Malic acid: Very widely distributed; predominating in apples, pears, cherries, gooseberries, strawberries, raspberries, and mountain-ash berries. Not extracted for use.

Citric acid: Found in lemons, oranges, tomatoes, currants, gooseberries, raspberries, strawberries, and a large number of other fruits, generally with malic and tartaric acids. Obtained from lemons for use.

Tartaric acid: Also widely distributed in most fruits not forming the chief acid, but constituting the acid of the grape. Manufactured from the deposit of fermenting grape-juice; used in baking-powders and in its salts, cream-of-tartar, and Rochelle salt.

Oxalic acid is sometimes found in small proportions in a few fruits. Reports vary as to its existence in the tomato.

Fresenius's analyses give the following as the average proportions of total acid, reduced to equivalent of malic acid:

Currant	2.04 per cent.
Raspberry	1.48 " "
Strawberry	1.31 " "
Sour cherry	1.28 " "
Apple	0.75 " "
Grape	0.74 " "
Peach	0.67 " "
Red pear	0.07 " "

The quantity of acids in fruits usually *diminishes during ripening.* The diminution is not, however, nearly so great as it appears to the taste, because the acid of ripe fruits is masked to the taste by the larger proportions of sugar and the pectous substances then present. The removal of acids is chiefly due to oxidation. It is not found that acids are neutralized, to any considerable extent, during ripening, by alkalies conveyed through the stem. The diminution of the acid in plums was shown definitely by the series of analyses before given from Mercadante. It is stated that the acids continue to oxidize away, after the sugar has reached its maximum and before it begins to diminish. Hence, perfect ripeness in fruit has been defined as that period during the maximum quantity of sugar when the quantity of acid is least. This will be, of course, just before the sugar begins to diminish.

It has been stated that both citric and malic acids are often found in unripe grapes, and are substituted by tartaric acid during the ripening. Oxalic acid is more often found in unripe than in ripe fruits. It is to be desired that closer determinations should be made as to the presence and proportion of oxalic acid in tomatoes and some other fruits. Any article of food containing oxalic acid (as the garden pie-plant) should probably be eaten with moderation, if at all.

A misapprehension sometimes occurs, from lack of reflection, as to the effect of sugar on the acidity of fruits. Sugar has no chemical effect upon acids. Its very sweet taste masks or overpowers to the sense the sour taste of free acids; but the acids remain free, all the same. Whatever effect the sugar eaten with fruits has on digestion and nutrition is due to the sugar itself; not to any change of the acids by the sugar, for there is no such change. Indeed, sugar approaches to the nature of an acid, though properly classed as a neutral body.

The varieties of tannic acids classed together as TANNIN are quite unlike the fruit acids above mentioned, both in sensible properties and in chemical relations. Only a few of the ripe edible fruits contain astringent acids, though these are found in many unripe fruits and in numerous ripe fruits not used for food. Most varieties of colored grapes contain a little tannin, deposited mostly in the skins and

seeds, and imparting a slight astringency to the juice, retained after fermentation. In the red wines from 0.08 to 0.2 per cent. of tannin is found. The decomposition of tannin, by a fermentation producing sugar, has been mentioned under the head of sugars. Tannin is also liable to oxidation with various products not including sugar.

The vegetable kingdom furnishes numerous compounds, known as GLUCOSIDES, which are capable of definite and distinctive fermentations, one of the fermentation-products in each instance being sugar. A number of these glucosides are found in fruits. One of the most important of these is *amygdalin*, a glucoside found in the fruits, leaves, etc., of plants of the almond family, especially in the kernels of the bitter-almond, peach, and cherry, the leaves of the cherry-laurel, and the bark of the wild-cherry.

Amygdalin, when obtained pure, is a white, odorless solid, with a taste both sweet and bitter. Taken alone it is not poisonous, even in considerable quantities. But if mixed with a substance named emulsin, and wetted, amygdalin begins at once to break up, with formation of three other compounds, as follows:

Amygdalin, 457 parts (by contact with emulsin and coöperation with water), produces:
1. Bitter-almond oil, 106 parts.
2. Hydrocyanic acid (or "prussic acid"), 27 parts.
3. Glucose, 360 parts.

In the plant, amygdalin is accompanied with the emulsin needful for its fermentation. During the ripening of the fruit, and in the maturity of the leaves and other parts, the amygdalin is constantly, though slowly, being transformed into the three products above named. The bitter-almond oil and hydrocyanic acid are volatile and odorous, and give the pleasant odor of peach-kernels, almonds, etc., familiar to every one. The rapidity of the chemical change is chiefly governed by the proportion of moisture, being greatly accelerated by wetting the bruised kernels or leaves, and stopped altogether by drying, while the moisture of the living plant permits only a gradual rate of the transformation. One of the products of this change is poisonous, the well-known hydrocyanic acid, or prussic acid, one-tenth of a grain of which is a full medicinal dose. The bitter-almond oil (known to chemists as benzoic aldehyde, and easily oxidized to benzoic acid) is not in the least poisonous (when separated from the hydrocyanic acid). It will be seen from the numbers of parts resulting from the change (as given above) that one part of hydrocyanic acid and four of bitter-almond oil are produced by sixteen parts of pure amygdalin. The amygdalin of the shops, in Europe, where it is somewhat used to generate hydrocyanic acid in medicine, yields from $\frac{1}{20}$ to $\frac{1}{25}$ of its weight of hydrocyanic acid. In exposure to the air, the hydrocyanic acid, being very volatile, is quickly dissipated, while the bitter-almond oil vaporizes more slowly. In most fruits of the

almond family the amygdalin and its products are obtained chiefly or only from the kernel, hence the well-known flavoring effect of leaving in the stones, or a few cracked stones, in canned fruits. Some of these fruits, however, have the amygdalin deposited in the sarcocarp (or edible portion). This is stated to be the case with black cherries.

The almond-flavor is a very grateful accompaniment of fruits and flowers, and it is provided by Nature in safe and wholesome proportions, but it has been so tampered with by the art of man that its use is now beset with dangers of several sorts. In the first place, there is the danger in concentrating what the Creator has diluted. The oxygen of the air itself is poisonous when concentrated. Bungling art is almost sure to "o'erstep the modesty of Nature" by using good things in hurtful excess. The essential oil of bitter-almonds extracted from cherry-laurel leaves, or from bitter-almond kernels, is liable to retain a poisonous proportion of the hydrocyanic acid, and its use in flavoring extracts, for pastry, etc., has now and then produced illness and even fatal results, more frequently with children. If made free from hydrocyanic acid, as the manufacturers should do, the essential oil is harmless in any quantity, and the essences, extracts, waters, etc., made from it can be used with entire safety. If long exposed to the air, the oil deposits a slight sediment of benzoic acid, which is harmless. The danger in the use of bitter-almond oil from the amygdaline of plants lies in possible neglect of removing the hydrocyanic acid. Then, in the next place, there is another substance which has the same odor as bitter-almond oil, viz., a substance named *nitrobenzine* and sometimes designated "oil of mirbane," a body which is in itself very poisonous, either when taken into the stomach or inhaled into the lungs. It it is a very cheap substitute for actual bitter-almond oil, which it resembles only in the odor. It has been manufactured for twenty years, from coal-tar, great quantities of it being used in making aniline dyes. It is from this article that many cheap grades of soap have been saturated with the smell of almond, of late years, quite to the discredit of the flavor. Unscrupulous manufacturers have used it in confectionery, and the danger of its substitution in culinary extracts besets the public, who cannot employ analysts for the examination of every manufactured article purchased for the kitchen. But if chemical art furnished a temptation for the improper substitution of nitrobenzine, it has lately compensated for it by discovering the manufacture of actual bitter-almond oil itself, a pure article, at once real and artificial, and by means so cheap that they are likely to remove the temptation to use nitrobenzine. German samples of this new product were on exhibition at the Centennial last summer.

4. Flavoring Ethers.—Many other odor-giving constituents, besides that of the almond, are subjects of chemical manufacture. For example, oil of wintergreen (found in the berry and other parts) is

well known to be chiefly salicylate of methyl, readily prepared from salicylic acid and wood-alcohol; and the oil or essence of pineapple is precisely butyric ether, manufactured largely from waste materials. Acetate of amyl and valerate of amyl are supposed to represent the flavor of the apple and the pear, but how accurately they coincide with the actual flavor-substances of these fruits has not been demonstrated. Formate of ethyl, another compound ether, is used in so-called peach-essence. Numerous *fruit-flavors*, used for culinary extracts and largely for soda-fountain sirups, are manufactured as mixtures of ethers, by recipes varying with different manufacturers. Many of these, resting on no due authority, are unwholesome mixtures, often spurious imitations of the true fruit-flavors, and again hurtful by reason of excessive proportions. As to the chemistry of the production of flavoring ethers in plants, some guesses were presented under the head of sugar fermentation.

5. ALKALOIDS.—*Substances strongly affecting the nervous system*, as medicines or poisons, of course do not occur in the edible fruits, and we are not in the habit of placing potent compounds among the constituents of fruits as a class; nevertheless, when we think of it, no small proportion of the banes and antidotes of the vegetable kingdom is matured in seeds and their coverings. In the poppy-fruit, the capsule or pericarp furnishes at least sixteen distinct alkaloids, including morphine, while the seeds are harmless, and yield an oil much used for food. In the fruit of the nux-vomica, the seeds are deadly with strychnine and other poisonous alkaloids, while the juicy pulp is but very slightly impregnated with these bitter poisons (Fluckiger and Hanbury, "Pharmacographia," p. 384). The seeds of henbane, and stramonium, and the Calabar-bean, contain potent alkaloids. The unripe tomato often contains traces of solanine, a poisonous alkaloid, which disappears during ripening, probably by a glucosic fermentation. The same alkaloid is sometimes found in the green or exposed parts of potato-tubers.

Many of the vegetable alkaloids are stable compounds, having clearly-marked chemical characteristics. Some of the opium-alkaloids closely resemble others in their composition. Different species of the same family often yield the same alkaloids. The theobromine of the chocolate-nut can be changed by the chemist into caffeine, the alkaloid of the coffee-berry. Such an insight has been obtained of the structure of conine, the alkaloid of the classic poison-hemlock, that it has been formed from inorganic materials, through the processes of the laboratory. But no evidence has been obtained as to the steps through which alkaloids are formed in the living plants.

It is little enough we know of the productive chemistry of plants. As, at the beginning, we had need to plead ignorance of plant-constituents, still more, at the end of our brief survey, must we declare ignorance of the chemical genesis of those constituents. We can

only obtain such glimpses of the progressive order of plant-chemistry, and we have only such a distant view of chemical action itself, as can give us some hints of the order, harmony, and grandeur, of the molecular changes going on in ripening fruits before us. None the less for our ignorance, the forces each season complete their work and drop their bountiful products into our hands.

ADDRESSES OF ELIOT AND MARSH,

AT THE OPENING OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

Address of President C. W. Eliot.

IN whose honor are the chief personages of the nation, State, and city, here assembled? Whose palace is this? What divinity is worshiped in this place? We are assembled here to own with gratitude the beneficent power of natural science; to praise and thank its votaries, and to dedicate this splendid structure to its service. The power to which we here do homage is the accumulated intelligence of our race applied generation after generation to the study of Nature; and this palace is the storehouse of the elaborated materials which that intelligence has garnered, ordered, and illuminated. What has natural science done for mankind that it should be thus honored? In the brief moments allotted to me I can but mention three pregnant results of the scientific study of Nature.

In the first place, natural science has engendered a peculiar kind of human mind—the searching, open, humble mind, which, knowing that it cannot attain unto all truth, or even to much new truth, is yet patiently and enthusiastically devoted to the pursuit of such little new truth as is within its grasp, having no other end than to learn, prizing above all things accuracy, thoroughness, and candor, in research, proud and happy not in its own single strength, but in the might of that host of students, whose past conquests make up the wondrous sum of present knowledge, whose sure future triumphs each humblest worker in imagination shares. Within the last four hundred years this typical scientific mind has gradually come to be the kind of philosophic mind most admired by the educated class; indeed, it has come to be the only kind of mind, except the poetic, which commands the respect of scholars, whatever their department of learning. In every field of study, in history, philology, philosophy, and theology, as well as in natural history and physics, it is now the scientific spirit, the scientific method, which prevails. The substitution in the esteem of reasonable men of this receptive, fore-reaching mind for the dogmatic, overbearing, closed mind, which assumes that it already possesses all essential truth, and is entitled to the exclusive interpretation of it, is

a most beneficent result of the study of natural history and physics. It is an achievement which has had much to do with the modern increase of liberty in human society, liberty individual, political and religious; it is an achievement of the highest promise for the future of the race.

The second result which I wish to specify is the stupendous doctrine of hereditary transmission, which during the past thirty years, or within the lifetime of most of those who hear me, natural science has developed and enforced by observations and comparisons covering the whole field of organized life. This conception is far from being a new one. Our race has long practised, though fitfully and empirically, upon some crude and fragmentary forms of this idea. Tribes, clans, castes, orders of nobility, and reigning families, are familiar illustrations of the sway of this idea; in killing, banishing, and confining criminals mankind has in all ages been defending itself, blindly, to be sure, but effectually, against evils which incidentally flow from hereditary transmission; but it has been reserved for natural science in this generation to demonstrate the universality of this principle, and its controlling influence upon the families, nations, and races of men, as well as upon all lower orders of animate beings. It is fitting that natural history should have given this demonstration to the world; for the basis of systematic natural history is the idea of species, and the idea of species is itself founded upon the sureness of hereditary transmission, upon the ultimate fact that individual characteristics are hereditable. As the knowledge of heredity, recently acquired by science, permeates society, it will profoundly affect social customs, public legislation, and governmental action. It will throw additional safeguards around the domestic relations; enhance the natural interest in vigorous family stocks; guide wisely the charitable action of the community; give a rational basis for penal legislation; and promote both the occasional production of illustrious men and the gradual improvement of the masses of mankind. These moral benefits will surely flow from our generation's study of heredity.

Finally, modern science has discovered and set forth the magnificent idea of the continuity of creation. It has proved that the development of the universe has been a progress from good to better, a progress not without reactions and catastrophes, but still a benign advance toward ever higher forms of life, with ever greater capacities for ever finer enjoyments. It has laid a firm foundation for man's instinctive faith in his own future. From the sight and touch of what the eternal past has wrought, it deduces a sure trust in what the eternal future has in store.

"And present gratitude
Insures the future's good;
And for the things I see
I trust the things to be."

It has thus exalted the idea of God—the greatest service which can be rendered to humanity. "Each age must worship its own thought of God," and each age may be judged by the worthiness of that thought. In displaying the uniform, continuous action of unrepenting Nature in its march from good to better, science has inevitably directed the attention of men to the most glorious attributes of that Divine intelligence which acts through Nature with the patience of eternity and the fixity of all-foreseeing wisdom. Verily, the infinite, present Creator is worshiped in this place. A hundred lifetimes ago a Hebrew seer gave utterance to one of the grandest thoughts that ever mind of man conceived, but applied it only to his own little nation, and coupled it with barbarous denunciation of that nation's enemies. This thought, tender and consoling toward human weakness and insignificance as a mother's embrace, but sublime also as the starry heights and majestic as the onward sweep of ages, science utters as the sum of all its teachings, as the supreme result of all its searching and its meditation, and applies alike to the whole universe and to its last atom—"the eternal God is thy refuge, and underneath are the everlasting arms."

Address of Professor O. C. Marsh.

The opening of this Museum to day is an important event in the annals of American science, and one from which great results are sure to follow. We see around us here, already, treasures of Nature from every land, and representing all periods of the earth's history. Not merely a few typical specimens, as in most new museums, but rich series, illustrating the marvelous diversity of Nature, both in the present and in the past. Such treasures, arranged with system, and to the best advantage, as here, arrest the attention of every observer, and invite study. This alone is a grand work accomplished, and yet, we are told, this is but the beginning.

The great museums of the world are in the great cities; and it is fitting that New York, one of the few great centres of culture, should at last take her proper place in science, and found a museum, worthy of herself, for the diffusion of knowledge among her citizens. But there is something higher than the diffusion of knowledge to strive for here, and that is the increase of knowledge. The old idea of a museum was a show-room; the modern idea makes it a workshop as well. If this institution is to hold high rank in science, as we hope, it will not be in consequence of the spacious halls before us, crowded though they be with the rarest of Nature's products; but, rather, it will come through the small work-rooms in the attic, where the naturalist, with microscope or scalpel, has patiently worked out discoveries that add to the sum of human knowledge. This Museum will fail of its highest good, fail even to achieve more than a local influence, un-

less the work-rooms above are made the most important feature of the whole. These vast collections will spread the elements of natural science among the people of New York, and the surrounding region; but the quiet workers in the attic, who pursue science for its own sake, will bring the Museum renown throughout the world.

There is yet a more important reason for making this institution a centre for original research. The science of to-day stands face to face with great problems. The antiquity of man, the origin of the human race, and even the origin of life itself, are among the questions which the present age submits to science, and to which it demands an answer. If these problems are to be solved by science, America must do her full share of the work, for the materials are here. In all that pertains to ancient life, the Western Continent possesses countless treasures, unknown in other lands. These, as I believe, are to unlock many mysteries in biology, and render important aid toward the solution of the profounder questions I have named. American science can thus repay its debt to the Old World, where science began, and gathering new facts, from broader and richer fields within her own borders, carry forward, with the vigor and enthusiasm of youth, the never-ending search for truth.

If the American Museum of Natural History, opened to-day under such favorable auspices, does not take a prominent part in this great work, it will not do justice to its founders, or to its opportunities. But with such a foundation as we have here, and such resources as wait to unfold their secrets within walls yet to be reared on this commanding site, I venture to predict for natural science in America greater triumphs than have hitherto been won in any land.

SPONTANEOUS GENERATION.

By Prof. JOHN TYNDALL, F. R. S.

I.

WITHIN ten minutes' walk of a little cottage which I have recently built in the Alps, there is a small lake, fed by the melted snows of the upper mountains. During the early weeks of summer no trace of life is to be discerned in this water; but invariably toward the end of July, or the beginning of August, swarms of tailed organisms are seen enjoying the sun's warmth along the shallow margins of the lake, and rushing with audible patter into the deeper water at the approach of danger. The origin of this periodic crowd of living things is by no means obvious. For years I had never noticed in the lake either an adult frog, or the smallest fragment of frog spawn;

so that, were I not otherwise informed, I should have found the conclusion of Mathiole a natural one, namely, that tadpoles are generated in lake-mud by the vivifying action of the sun.

The checks which experience alone can furnish being absent, the spontaneous generation of creatures quite as high as the frog in the scale of being was assumed for ages to be a fact. Here, as elsewhere, the dominant mind of Aristotle stamped its notions on the world at large. For nearly twenty centuries after him men found no difficulty in believing in cases of spontaneous generation which would now be rejected as monstrous by the most fanatical supporter of the doctrine. Shell-fish of all kinds were considered to be without parental origin. Eels were supposed to spring spontaneously from the fat ooze of the Nile. Caterpillars were the spontaneous products of the leaves on which they fed, while winged insects, serpents, rats, and mice, were all thought capable of being generated without sexual intervention.

The most copious source of this life without an ancestry was putrefying flesh, and, lacking the checks imposed by fuller investigation, the conclusion that flesh possesses and exerts this generative power is a natural one. I well remember when a child of ten or twelve seeing a joint of imperfectly salted beef cut into, and coils of maggots laid bare within the mass. Without a moment's hesitation I jumped to the conclusion that these maggots had been spontaneously generated in the meat. I had no knowledge which could qualify or oppose this conclusion, and for the time it was irresistible. The childhood of the individual typifies that of the race, and the belief here enunciated was that of the world for nearly two thousand years.

To the examination of this very point the celebrated Francesco Redi, physician to the Grand-dukes Ferdinand II. and Cosmo III. of Tuscany, and a member of the Academy del Cimento, addressed himself in 1668. He had seen the maggots of putrefying flesh, and reflected on their possible origin. But he was not content with mere reflection, nor with the theoretic guess-work which his predecessors had founded upon their imperfect observations. Watching meat during its passage from freshness to decay, prior to the appearance of maggots he invariably observed flies buzzing round the meat and frequently alighting on it. The maggots, he thought, might be the half-developed progeny of these flies.

The inductive guess precedes experiment, by which, however, it must be finally tested. Redi knew this, and acted accordingly. Placing fresh meat in a jar and covering the mouth with paper, he found that though the meat putrefied in the ordinary way, it never bred maggots, while the same meat placed in open jars soon swarmed with these organisms. For the paper cover he then substituted fine gauze, through which the odor of the meat could rise. Over it the flies buzzed, and on it they laid their eggs, but, the meshes being too

small to permit the eggs to fall through, no maggots were generated in the meat. They were, on the contrary, hatched upon the gauze. By a series of such experiments Redi destroyed the belief in the spontaneous generation of maggots in meat, and with it doubtless many related beliefs. The combat was continued by Vallisneri, Schwammerdam, and Réaumur, who succeeded in banishing the notion of spontaneous generation from the scientific minds of their day. Indeed, as regards such complex organisms as those which formed the subject of their researches, the notion was banished forever.

But the discovery and improvement of the microscope, though giving a death-blow to much that had been previously written and believed regarding spontaneous generation, brought also into view a world of life formed of individuals so minute—so close as it seemed to the ultimate particles of matter—as to suggest an easy passage from atoms to organisms. Animal and vegetable infusions exposed to the air were found clouded and crowded with creatures far beyond the reach of unaided vision, but perfectly visible to an eye strengthened by the microscope. With reference to their origin these organisms were called "infusoria." Stagnant pools were found full of them, and the obvious difficulty of assigning a germinal origin to existences so minute furnished the precise condition necessary to give new play to the notion of heterogenesis or spontaneous generation.

The scientific world was soon divided into two hostile camps, the leaders of which alone can here be briefly alluded to. On the one side we have Buffon and Needham, the former postulating his "organic molecules," and the latter assuming the existence of a special "vegetative force" which drew the molecules together so as to form living things. On the other side we have the celebrated Abbé Lazzaro Spallanzani, who in 1777 published results counter to those announced by Needham in 1748, and obtained by methods so precise as to completely overthrow the convictions based upon the labors of his predecessor. Charging his flasks with organic infusions, he sealed their necks with the blow-pipe, subjected them in this condition to the heat of boiling water, and subsequently exposed them to temperatures favorable to the development of life. The infusions continued unchanged for months, and when the flasks were subsequently opened no trace of life was found.

Here I may forestall matters so far as to say that the success of Spallanzani's experiments depended wholly on the locality in which he worked. The air around him must have been free from the more obdurate infusorial germs, for otherwise the process he followed would, as was long afterward proved by Wyman, have infallibly yielded life. But his refutation of the doctrine of spontaneous generation is not the less valid on this account. Nor is it in any way upset by the fact that others in repeating his experiments obtained life when he obtained none. Rather is the refutation strengthened by

such differences. Given two experimenters equally skillful and equally careful, operating in different places on the same infusions, in the same way, and assuming the one to obtain life while the other fails to obtain it; then its well-established absence in the one case proves that some ingredient foreign to the infusion must be its cause in the other.

Spallanzani's sealed flasks contained but small quantities of air, and as oxygen was afterward shown to be generally essential to life, it was thought that the absence of life observed by Spallanzani might have been due to the lack of this vitalizing gas. To dissipate this doubt, Schulze in 1836 half-filled a flask with distilled water, to which animal and vegetable matters were added. First boiling his infusion to destroy whatever life it might contain, Schulze sucked daily into his flask air which had passed through a series of bulbs containing concentrated sulphuric acid, where all germs of life suspended in the air were supposed to be destroyed. From May to August this process was continued without any development of infusorial life.

Here, again, the success of Schulze was due to his working in comparatively pure air, but even in such air his experiment is a very risky one. Germs will pass, unwetted and unscathed, through sulphuric acid, unless the most special care is taken to detain them. I have repeatedly failed, by repeating Schulze's experiments, to obtain his results. Others have failed likewise. The air passes in bubbles through the bulbs, and, to render the method secure, the passage of the air must be so slow as to cause the whole of its floating matter, even to the core of each bubble, to touch the surrounding liquid. But, if this precaution be observed, water will be found quite as effectual as sulphuric acid. By the aid of an air pump, in a highly-infective atmosphere, I have thus drawn air for weeks without intermission, first through bulbs containing water, and afterward through vessels containing organic infusions, without any appearance of life. The germs were not killed, but they were effectually intercepted, while the objection that the air had been injured by being brought into contact with strongly corrosive substances was avoided.

The brief paper of Schulze, published in Poggendorf's *Annalen* for 1836, was followed in 1837 by another short and pregnant communication by Schwann. Redi, as we have seen, traced the maggots of putrefying flesh to the eggs of flies. But he did not and he could not know the meaning of putrefaction itself. He had not the instrumental means to inform him that *it* also is a phenomenon attendant on the development of life. This was first proved in the paper now alluded to. Schwann placed flesh in a flask filled to one-third of its capacity with water, sterilized the flask by boiling, and then supplied it for months with calcined air. Throughout this time "there appeared no mould, no infusoria, no putrefaction; the flesh remained unaltered, while the liquid continued as clear as it was immediately after boiling."

Schwann then varied his experimental argument, with no alteration in the result. His final conclusion was, that putrefaction is due to decompositions of organic matter attendant on the multiplication therein of minute organisms. These organisms were derived not from the air, but from something contained in the air, which was destroyed by a sufficiently high temperature. There never was a more determined opponent of the doctrine of spontaneous generation than Schwann, though a strange attempt was made a year and a half ago to enlist him and others equally opposed to it on the side of the doctrine.

The physical character of the agent which produces putrefaction was further revealed by Helmholtz in 1843. By means of a membrane he separated a sterilized putrescible liquid from a putrefying one. The sterilized infusion remained perfectly intact. Hence it was not the liquid of the putrefying mass—for it could freely diffuse through the membrane—but something contained in the liquid, and which was stopped by the membrane, that caused the putrefaction. In 1854 Schroeder and Von Dusch struck into this inquiry, which was subsequently followed up by Schroeder alone. These able experimenters employed plugs of cotton-wool to filter the air supplied to their infusions. Fed with such air, in the great majority of cases the putrescible liquids remained perfectly sweet after boiling. Milk formed a conspicuous exception to the general rule. It putrefied after boiling, though supplied with carefully-filtered air. The researches of Schroeder bring us up to the year 1859.

In that year a book was published which seemed to overturn some of the best-established facts of previous investigators. Its title was "Hétérogénie," and its author was F. A. Pouchet, Director of the Museum of Natural History at Rouen. Ardent, laborious, learned, full not only of scientific but of metaphysical fervor, he threw his whole energy into the inquiry. Never did a subject require the exercise of the cold, critical faculty more than this one—calm study in the unraveling of complex phenomena, care in the preparation of experiments, care in their execution, skillful variation of conditions, and incessant questioning of results, until repetition had placed them beyond doubt or question. To a man of Pouchet's temperament, the subject was full of danger—danger not lessened by the theoretic bias with which he approached it. This is revealed by the opening words of his preface: "Lorsque, par la méditation, il fut évident pour moi que la génération spontanée était encore l'un des moyens qu'emploie la nature pour la reproduction des êtres, je m'appliquai à découvrir par quels procédés on pouvait parvenir à en mettre les phénomènes en évidence." It is needless to say that such a prepossession required a strong curb. Pouchet repeated the experiments of Schulze and Schwann with results diametrically opposed to theirs. He heaped experiment upon experiment, and argument upon argument, spicing with the sarcasm of the advocate the logic of the man of science. In

view of the multitudes required to produce the observed results, he ridiculed the assumption of atmospheric germs. This was one of his strongest points. "Si les Proto-organismes que nous voyons pulluler partout et dans tout, avaient leurs germes disséminés dans l'atmosphère, dans la proportion mathématiquement indispensable à cet effet, l'air en serait totalement obscurci, car ils devraient s'y trouver beaucoup plus serrés que les globules d'eau qui forment nos nuages épais. Il n'y a pas là la moindre exagération." Recurring to the subject, he exclaims, "L'air dans lequel nous vivons aurait presque la densité du fer." There is often a virulent contagion in a confident tone, and this hardihood of argumentative assertion was sure to influence minds swayed not by knowledge, but by authority. Had Pouchet known that "the blue ethereal sky" is formed of suspended particles, through which the sun freely shines, he would hardly have ventured upon this line of argument.

Pouchet's pursuit of this inquiry strengthened the conviction with which he began it, and landed him in downright credulity in the end. I do not question his ability as an observer, but the inquiry needed a disciplined experimenter. This latter implies not mere ability to look at things as Nature offers them to our inspection, but to force her to show herself under conditions prescribed by the experimenter himself. Here Pouchet lacked the necessary discipline. Yet the vigor of his onset raised clouds of doubt, which for a time obscured the whole field of inquiry. So difficult indeed did the subject seem, and so incapable of definite solution, that when Pasteur made known his intention to take it up, his friends Biot and Dumas expressed their regret, earnestly exhorting him to set a definite and rigid limit to the time he purposed spending in this apparently unprofitable field.[1]

Schooled by his education as a chemist, and by special researches on the closely related question of fermentation, Pasteur took up this subject under particularly favorable conditions. His work and his culture had given strength and finish to his natural aptitudes. In 1862, accordingly, he published a paper "On the Organized Corpuscles existing in the Atmosphere," which must forever remain classical. By the most ingenious devices he collected the floating particles of the air surrounding his laboratory in the Rue d'Ulm, and subjected them to microscopic examination. Many of them he found to be organized particles. Sowing them in sterilized infusions, he obtained abundant crops of microscopic organisms. By more refined methods he repeated and confirmed the experiments of Schwann, which had been contested by Pouchet, Montegazza, Joly, and Musset. He also confirmed the experiments of Schroeder and Von Dusch. He showed

[1] "Je ne conseillerais à personne," said Dumas to his already famous pupil, "de rester trop longtemps dans ce sujet."—("Annales de Chemie et de Physique," 1862, vol. lxiv., p. 22.) Since that time the illustrious Perpetual Secretary of the Academy of Sciences has had good reason to revise this "counsel."

that the cause which communicated life to his infusions was not uniformly diffused through the air; that there were aërial interspaces which possessed no power to generate life. Standing on the Mer de Glace, near the Montanvert, he snipped off the ends of a number of hermetically-sealed flasks containing organic infusions. One out of twenty of the flasks thus supplied with glacier air showed signs of life afterward, while eight out of twenty of the same infusions, supplied with the air of the plains, became crowded with life. He took his flasks into the caves under the Observatory of Paris, and found the still air in these caves devoid of generative power. These and other experiments, carried out with a severity perfectly obvious to the instructed scientific reader, and accompanied by a logic equally severe, restored the conviction that, even in these lower reaches of the scale of being, life does not appear without the operation of antecedent life.

The main position of Pasteur, though often assailed, has never yet been shaken. It has, on the contrary, been strengthened by practical researches of the most momentous kind. He has applied the knowledge won from his inquiries to the preservation of wine and beer, to the manufacture of vinegar, to the staying of the plague which threatened utter destruction to the silk-husbandry of France, and to the examination of other formidable diseases which assail the higher animals, including man. His relation to the improvements which Prof. Lister has introduced into surgery is shown by a letter quoted in his "Études sur la Bière."[1] Prof. Lister there expressly thanks Pasteur for having given him the only principle which could have conducted the antiseptic system to a successful issue. The strictures regarding Pasteur's defects of reasoning, to which we have been lately accustomed, delivered with a tone of supercilious contempt, where reverent teachableness would have been the fitting state of mind, throw abundant light upon their author, but none upon Pasteur.

Redi, as we have seen, proved the maggots of putrefying flesh to be derived from the eggs of flies; Schwann proved putrefaction itself to be the concomitant of far lower forms of life than those dealt with by Redi. Our knowledge here, as elsewhere in connection with this subject, has been vastly extended by Prof. Cohn, of Breslau. "No putrefaction," he says, "can occur in a nitrogenous substance if its bacteria be destroyed and new ones prevented from entering it. Putrefaction begins as soon as bacteria, even in the smallest numbers, are admitted either accidentally or purposely. It progresses in direct proportion to the multiplication of the bacteria, it is retarded when they exhibit low vitality, and is stopped by all influences which either hinder their development or kill them. All bactericidal media are therefore antiseptic and disinfecting."[2] It was these organisms act-

[1] P. 43.

[2] In his last excellent memoir, Cohn expresses himself thus: "Wer noch heut die Fäulniss von einer spontanen Dissociation der Proteinmolecule, oder von einem unorgani-

ing in wound and abscess which so frequently converted our hospitals into charnel-houses, and it is their destruction by the antiseptic system that now renders justifiable operations which no surgeon would have attempted a few years ago. The gain is immense—to the practising surgeon as well as to the patient practised upon. Contrast the anxiety of never feeling sure whether the most brilliant operation might not be rendered nugatory by the access of a few particles of unseen hospital-dust, with the comfort derived from the knowledge that all power of mischief on the part of such dust has been surely and certainly annihilated. But the action of living contagia extends beyond the domain of the surgeon. The power of reproduction and indefinite self-multiplication which is characteristic of living things, coupled with the undeviating fact of contagia "breeding true," has given strength and consistency to a belief long entertained by penetrating minds that epidemic diseases generally are the concomitants of parasitic life. "There begins to be faintly visible to us a vast and destructive laboratory of Nature wherein the diseases which are most fatal to animal life, and the changes to which dead organic matter is passively liable, appear bound together by what must at least be called a very close analogy of causation."[1] According to this view, which, as I have said, is daily gaining converts, a contagious disease may be defined as a conflict between the person smitten by it and a specific organism which multiplies at his expense, appropriating his air and moisture, disintegrating his tissues, or poisoning him by the decompositions incident to its growth.

During the ten years extending from 1859 to 1869, researches on radiant heat in its relations to the gaseous form of matter occupied my continual attention. When air was experimented on, I had to cleanse it effectually of floating matter, and, while doing so, I was surprised to notice that, at the ordinary rate of transfer, such matter passed freely through alkalies, acids, alcohols, and ethers. The eye being kept sensitive by darkness, a concentrated beam of light was found to be a most searching test for suspended matter both in water and in air—a test indeed indefinitely more searching and severe than that furnished by the most powerful microscope. With the aid of such a beam I examined air filtered by cotton-wood, air long kept free from agitation, so as to allow the floating matter to subside, calcined air, and air filtered by the deeper cells of the human lungs. In all cases the correspondence between my experiments and those of Schroeder, Pasteur, and Lister, in regard to spontaneous generation, was perfect. The air which they found inoperative was proved by

sirten Ferment ableitet, oder gar aus 'Stickstoffsplittern' die Balken zur Stütze seiner Fäulnisstheorie zu zimmern versucht, hat zuerst den Satz 'keine Fäulniss ohne Bacterium Termo' zu widerlegen."

[1] "Report of the Medical Officer of the Privy Council," 1874, p. 5.

the luminous beam to be optically pure and therefore germless. Having worked at the subject both by experiment and reflection, on Friday evening, the 21st of January, 1870, I brought it before the members of the Royal Institution. Two or three months subsequently, for sufficient practical reasons, I ventured to direct public attention to the subject in a letter to the *Times*. Such was my first contact with this important question.

This letter, I believe, gave occasion for the first public utterance of Dr. Bastian in relation to this question. He did me the honor to inform me, as others had informed Pasteur, that the subject "pertains to the biologist and physician." He expressed "amazement" at my reasoning, and warned me that before what I had done could be undone "much irreparable mischief might be occasioned." With far less preliminary experience to guide and warn him, Dr. Bastian was far bolder than Pouchet in his experiments, and far more adventurous in his conclusions. With organic infusions he obtained the results of his celebrated predecessor, but he did far more—the atoms and molecules of inorganic liquids passing under his manipulation into those more "complex chemical compounds" which we dignify by calling them "living organisms."[1] For five years, or thereabouts, Dr. Bastian ploughed the field without impediment from me, and, now that one can overlook the work, I am bound in truth to say that very wonderful ploughing it has been. As regards the public who take an interest in such things, and apparently also as regards a large portion of the medical profession, he certainly succeeded in restoring the subject to a state of uncertainty similar to that which followed the publication of Pouchet's volume in 1859.

It is desirable that this uncertainty should be removed from the public mind, and doubly desirable on practical grounds that it should be removed from the minds of medical men. In the present article, therefore, I propose discussing this question face to face with some eminent and fair-minded member of the medical profession who, as regards spontaneous generation, entertains views adverse to mine. Such a one it would be easy to name; but it is perhaps better to rest in the impersonal. I shall therefore simply call my proposed co-inquirer my friend. With him at my side I shall endeavor, to the best of my ability, so to conduct this discussion that he who runs may read, and that he who reads may understand.

Let us begin at the beginning. I ask my friend to step into the laboratory of the Royal Institution, where I place before him a basin of thin turnip-slices barely covered with distilled water kept at a temperature of 120° Fahr. After digesting the turnip for four or

[1] "It is further held that bacteria or allied organisms are prone to be engendered as correlative products, coming into existence in the several fermentations, just as independently as other less complex chemical compounds."—(Bastian, "Transactions of the Pathological Society," vol. xxvi., p. 258.)

five hours we pour off the liquid, boil it, filter it, and obtain an infusion as clear as filtered drinking-water. We cool the infusion, test its specific gravity, and find it to be 1006 or higher—water being 1000. A number of small, clean, empty flasks, of the shape here shown, are before us. One of them is slightly warmed with a spirit-lamp, and its open end is then dipped into the turnip-infusion. The warmed glass is afterward chilled, the air within the flask cools, contracts, and is followed in its contraction by the infusion. Thus we get a small quantity of liquid into the flask. We now heat this liquid carefully. Steam is produced, which issues from the open neck, carrying the air of the flask along with it. After a few seconds' ebullition, the open neck is again plunged into the infusion. The steam within the flask condenses, the liquid enters to supply its place, and in this way we fill our little flask to about four-fifths of its volume. This description is typical; we may thus fill a thousand flasks with a thousand different infusions.

I now ask my friend to notice a trough made of sheet-copper, with two rows of handy little Bunsen burners underneath it. This trough, or bath, is nearly filled with oil; a piece of thin plank constitutes a kind of lid for the oil-bath. The wood is perforated with circular apertures wide enough to allow our small flask to pass through and plunge itself in the oil, which has been heated, say, to 250° Fahr. Clasped all round by the hot liquid, the infusion in the flask rises to its boiling-point, which is not sensibly over 212° Fahr. Steam issues from the open neck of the flask, and the boiling is continued for five minutes. With a pair of small brass tongs an assistant now seizes the neck near its junction with the flask, and partially lifts the latter out of the oil. The steam does not cease to issue, but its violence is abated. With a second pair of tongs held in one hand, the neck of the flask is seized close to its open end, while with the other hand a Bunsen's flame or an ordinary spirit-flame is brought under the middle of the neck. The glass reddens, whitens, softens, and as it is gently drawn out the neck diminishes in diameter, until the canal is completely blocked up. The tongs with the fragment of severed neck being withdrawn, the flask, with its contents diminished by evaporation, is lifted from the oil-bath perfectly sealed hermetically.

Sixty such flasks filled, boiled, and sealed, in the manner described, and containing strong infusions of beef, mutton, turnip, and cucumber, are carefully packed in saw-dust and transported to the Alps. Thither, to an elevation of about 7,000 feet above the sea, I invite my co-inquirer to accompany me. It is the month of July, and the

weather is favorable to putrefaction. We open our box at the Bel-Alp, and count out fifty-four flasks, with their liquids as clear as filtered drinking-water. In six flasks, however, the infusion is found muddy. We closely examine these, and discover that every one of them has had its fragile end broken off in the transit from London. Air has entered the flasks, and the observed muddiness is the result. My colleague knows as well as I do what this means. Examined with a pocket-lens, or even with a microscope of insufficient power, nothing is seen in the muddy liquid; but regarded with a magnifying power of a thousand diameters or so, what an astonishing appearance does it present! Leeuwenhoek estimated the population of a single drop of stagnant water at 500,000,000: probably the population of a drop of our turbid infusion would be this many times multiplied. The field of the microscope is crowded with organisms, some wabbling slowly, others shooting rapidly across the microscopic field. They dart hither and thither like a rain of minute projectiles; they pirouette and spin so quickly round, that the retention of the retinal impression transforms the little living rod into a twirling wheel. And yet the most celebrated naturalists tell us that they are vegetables. From the rod-like shape which they so frequently assume, these organisms are called bacteria—a term, be it here remarked, which covers organisms of very diverse kinds.

Has this multitudinous life been spontaneously generated in these six flasks, or is it the progeny of living germinal matter carried into the flasks by the entering air? If the infusions have a self-generative power, how are the sterility and consequent clearness of the fifty-four uninjured flasks to be accounted for? My colleague may urge—and fairly urge—that the assumption of germinal matter is by no means necessary; that the air itself may be the one thing needed to wake up the dormant infusions. We will examine this point immediately. But I would meanwhile remind my friend that I am working on the exact lines laid down by our most conspicuous heterogenist. He distinctly affirms that the withdrawal of the atmospheric pressure above the infusion favors the production of organisms; and he accounts for their absence in tins of preserved meat, fruit, and vegetables, by the hypothesis that fermentation *has* begun in such tins, that gases *have* been generated, the pressure of which has stifled the incipient life and stopped its further development.[1] This is Dr. Bastian's theory of preserved meats. Its author has never, to my knowledge, pierced a tin of preserved meat, fruit, or vegetable, under water with a view of testing its truth. Had he done so, he would have found it erroneous. In well-preserved tins I have invariably found, not an outrush of gas, but an inrush of water, when the tin was perforated. I have noticed this recently in tins which have lain perfectly good for sixty-three years in the Royal Institution. Modern tins, subjected to

[1] "Beginnings of Life," vol. i., p. 418.

the same test, yielded the same result. From time to time, moreover, during the last two years, I have placed glass tubes, containing clear infusions of turnip, hay, beef, and mutton, in iron bottles, and subjected them to air-pressures varying from ten to twenty-seven atmospheres—pressures, it is needless to say, far more than sufficient to tear a preserved meat-tin to shreds. After ten days these infusions were taken from their bottles rotten with putrefaction and teeming with life. Thus collapses an hypothesis which had no rational foundation, and which could never have seen the light had the slightest attempt been made to verify it.

Our fifty-four vacuous and pellucid flasks also declare against this heterogenist. We expose them to a warm Alpine sun by day, and at night we suspend them in a warm kitchen. Four of them have been accidentally broken; but at the end of a month we find the fifty remaining ones as clear as at the commencement. There is no sign of putrefaction or of life in any of them. We divide these flasks into two groups of twenty-three and twenty-seven respectively (an accident of counting rendered the division uneven). The question now is whether the admission of air can liberate any generative energy in the infusions. Our next experiment will answer this question and something more. We carry the flasks to a hay-loft, and there, with a pair of steel pliers, snip off the sealed ends of the group of twenty-three. Each snipping-off is of course followed by an inrush of air. We now carry our twenty-seven flasks, our pliers, and a spirit-lamp, to a ledge overlooking the Aletsch glacier, about two hundred feet above the hay-loft, from which ledge the mountain falls almost precipitously to the northeast for about a thousand feet. A gentle wind blows toward us from the northeast—that is, across the crests and snow-fields of the Oberland mountains. We are, therefore, bathed by air which must have been for a good while out of practical contact with either animal or vegetable life. I stand carefully to leeward of the flasks, for no dust or particle from my clothes or body must be blown toward them. An assistant ignites the spirit-lamp, into the flame of which I plunge the pliers, thereby destroying all attached germs or organisms. Then I snip off the sealed end of the flask. Prior to every snipping the same process is gone through, no flask being opened without the previous cleansing of the pliers by the flame. In this way we charge our twenty-seven flasks with clean vivifying mountain-air.

We place the fifty flasks, with their necks open, over a kitchen-stove, in a temperature varying from 50° to 90° Fahr., and in three days find twenty-one out of the twenty-three flasks opened on the hay-loft invaded by organisms—two only of the group remaining free from them. After three weeks' exposure to precisely the same conditions, not one of the twenty-seven flasks opened in free air had given way. No germ from the kitchen-air had ascended the narrow necks,

the flasks being shaped to produce this result. They are still in the Alps, as clear, I doubt not, and as free from life as they were when sent off from London.[1]

What is my colleague's conclusion from the experiment before us? Twenty-seven putrescible infusions, first *in vacuo*, and afterward supplied with the most invigorating air, have shown no sign of putrefaction or of life. And as to the others, I almost shrink from asking him whether the hay-loft has rendered them spontaneously generative. Is not the inference here imperative that it is not the air of the loft—which is connected through a constantly-open door with the general atmosphere—but something contained in the air, that has produced the effects observed? What is this something? A sunbeam glinting through a chink in the roof or wall, and traversing the air of the loft, would show it to be laden with suspended dust-particles. Indeed, the dust is distinctly visible in the diffused daylight. Can *it* have been the origin of the observed life? If so, are we not bound by all antecedent experience to regard these fruitful particles as the germs of the life observed?

The name of Baron Liebig has been constantly mixed up with these discussions. "We have," it is said, "his authority for assuming that dead decaying matter can produce fermentation." True, but with Liebig fermentation was by no means synonymous with *life*. It will be observed, by the careful reader of Dr. Bastian's works, that whenever their author refers to this alleged power of decaying matter, he invariably couples with it the vague term "fermentation," thus softening the shock of the hypothesis which he insinuates rather than asserts. But our present intention is to brush all vagueness aside. We therefore ask, "Does *the life* of our flasks proceed from dead particles?" If my co-inquirer should reply "Yes," then I would ask him: "What warrant does Nature offer for such an assumption? Where, amid the multitude of vital phenomena in which her operations have been clearly traced, is the slightest countenance given to the notion that the sowing of dead particles can produce a living crop?" With regard to Baron Liebig, had he studied the revelations of the microscope in relation to these questions, a mind so penetrating could never have missed the significance of the facts revealed. He, however, neglected the microscope, and fell into error—but not into error so gross as that in support of which his authority has been invoked. Were he now alive, he would, I doubt not, repudiate the use often made of his name—Liebig's view of fermentation was at least a scientific one, founded on profound conceptions of molecular instability. But this view by no means involves the notion that the planting of dead particles—"Stickstoffsplittern," as Cohn contemptuously calls them—is followed by the sprouting of infusorial life.

[1] An actual experiment made three months ago at the Bel-Alp is here described.

SKETCH OF WALTER BAGEHOT.

WALTER BAGEHOT was born February, 1826, in the west of England, where his father, who survives him, was a leading partner in an old-established bank. A student in the University of London, he took the mathematical scholarship with his Bachelor's degree in 1846, and the gold medal in intellectual and moral philosophy with his Master's degree in 1848. He then studied law at Lincoln's Inn, and was called to the bar; he thoroughly liked but never practised this profession, being induced to abandon it by considerations of his health. Always delicate, the excessive work by which alone the position of a successful barrister can be won and maintained would doubtless have shortened the already too-brief life.

He early developed remarkable talent, but in his youth philosophy, poetry, and theology, had a larger share of his attention than the narrower and more prosaic studies which occupied him later, and upon which his fame will rest. In deciding, as he wisely did, to join his father in business, he was conscious of defects which might hinder his career as a banker and merchant. He was absent-minded about minutiæ, inattentive to trifles—he used to declare that he could never "add up," and habitual inaccuracies marked his mathematical exercises in college. He proved, however, to be very successful in business, and was gratified with this success won in practical pursuits, in spite of the metaphysical and poetic tendency which at one time earned for him the reputation of a dreamer. He somewhere says: "The great pleasure in life is doing what people say you can't do. Why did Mr. Disraeli take the duties of Chancellor of the Exchequer with so much relish? Because people said he was a novelist—an *ad captandum* man—who could not add up. No doubt it pleased his inmost soul to do the work of red-tape people better than those who could do nothing else."

He was always busy with his pen. During the early part of his life he wrote for the *National Review*, the *Inquirer*, and other periodicals, and proved himself to be a brilliant and able critic in various departments—finance, politics, and literature. His first book, called "Estimates of Some Englishmen and Scotchmen," published twenty years ago, and now long out of print, was a very remarkable volume of essays, that for some reason, perhaps the unfortunate title, failed to receive the attention it deserved.

In 1858 Bagehot married the eldest daughter of James Wilson, proprietor of the *Economist*. The marriage was a happy one, and led to the production of his most popular and original books; it brought him into connection with the higher world of politics; and eventually, on the death of his father-in-law, to the ownership and editorial control of the *Economist*, which paper he carried to the position of great power which it now has.

His first political work, a new edition of which was recently reviewed in THE POPULAR SCIENCE MONTHLY, is an analysis and explanation of that elaborate piece of mechanism—or rather, of that complex organism—"The English Constitution." He dispels many illusions and corrects many misconceptions concerning constitutions generally, and demonstrates the impossibility of framing a written document that will fulfill the functions discharged by the unwritten Constitution of England—the inevitable defects and weaknesses of made-to-order instruments being illustrated by examples drawn from the workings of our own much-vaunted ordinances, and the more recent instrument under which France is now governed.

In "Physics and Politics," Mr. Bagehot's first American book, the the growth of societies and states is treated according to the method of the evolution philosophy; it is a book which could only have been written by a man having a thorough knowledge of practical affairs, and a firm hold upon the theories of Spencer and Darwin. It is pronounced "clever" by the critics who do not accept those theories, but it is much more.

"Lombard Street," as its name indicates, deals with that abstruse and wayward subject, the "money-market," and is one of the best sources from which to learn the differences which exist between the realities of the "street" and the hypotheses of economists.

At the time of his death, March 24, 1877, he was engaged upon a book, some of the earlier chapters of which were published in the *Fortnightly Review* (February and May, 1876) under the title of "The Postulates of Political Economy;" they were able and timely, and it is to be hoped that the surmise that other of the chapters were so far forwarded as to warrant publication is correct.

Since his death his articles in the *Economist* upon the silver question have been reprinted, making a thin octavo volume; they lack completeness and finish, but are still the most valuable contribution to the subject, for he was the first to seek out and correctly correlate the causes that led to the decline and fluctuations in the price of silver.

This brief list comprises all that will be remembered as his "works," for, though a busy writer, his labor was mostly given to the leading articles in his paper. It is as a journalist that he will be chiefly missed. Though dealing with abstruse and technical topics, he never failed to make himself understood by men of ordinary cultivation and intelligence. His knowledge was so accurate and his grasp so strong as to command the respect of specialists, and yet his articles had the attention and interest of men whose only concern in or knowledge of the subjects was that obtained from Mr. Bagehot himself. In the abstract science with which he dealt he had the rare combination of a conversancy with the abstractions and a knowledge of the facts. He had the guessing faculty and the solid judgment of the man of business, and the trained reasoning power with which to test his guesses and value his conclusions.

CORRESPONDENCE.

"THE TIDES."

To the Editor of the Popular Science Monthly.

I MAKE the following comments on Prof. Schneider's second article about "The "Tides." All the objections to the statements in the first article remain in full force. The chief points of this second installment are two: 1. The disturbing action of the sun on the moon's motion; 2. The fall of the earth and the moon below their respective tangents, whereby it is sought to be proved that the moon approaches the earth at the time of opposition. If these two statements are shown to be wholly in error, the second article goes the way of the first.

On page 231, December number of this JOURNAL, we find this: "Thus our moon moves faster, and, by a radius drawn to the earth, describes an area greater for the time, and has its orbit less curved, and therefore approaches nearer to the earth in the syzygies than in the quadratures. . . . The moon's distance from the earth in the syzygies is to its distance in the quadratures, in round numbers, as 69 to 70."

This extract, which from its form would seem to be from a single paragraph, is in reality from two widely-separated parts of Newton's works, and is besides inaccurate. The phrase "in round numbers" is neither in the original nor in Motte's translation, but instead of it there is *cæteris paribus*, and it is hardly necessary to say that the phrases are not exactly equivalent. But let these slips pass. I give two other extracts from the "Principia," book iii., prop. xiv., cor. i.: "The fixed stars are immovable, seeing they keep the same positions to the aphelions and the nodes of the planets."

Herein is a double error:

Again, book iii., prop. xxxvii., cor. 3: "The density of the moon is to the density of the earth. . . . as 11 to 9."

This is very far from the truth, and scores of other mistakes in the "Principia" are known to those who are familiar with that work. So "the best of authority" is sometimes at fault, and his conclusions are not always to be accepted blindly and without investigation. But if they are to be so accepted, as Mr. Schneider's way of parading his authority seems to imply, would it not be better to accept Newton's theory of the tides, which is the true theory, and so make an end of it. But that theory excludes Prof. Schneider's.

If Newton's statement concerning the distance of the earth and moon in the syzygies and quadratures is to be taken without qualification, then it is plainly wrong; and the *mathematical proof* that it is wrong can be found more or less fully developed in any of the following works on astronomy, viz., those of Woodhouse, Herschel, Lardner, Gummere, Loomis, Norton, Olmsted, Robinson, and others.

Further, there is the practical proof of the correctness of the other view in the *calculated* and the *observed* positions of the moon for *every hour of every day in every year*, these positions being carefully noted by a score of observers every day. There is no more possibility of universal error in these observations and calculations than there is that a person who says that two and two are four should be in error on that point.

Prof. Schneider's first statement, then, is all wrong; and, this failing, the second goes with it. But it is also easily shown by his own figures that his conclusion should be exactly the opposite to what he makes it. He says, "The distance the earth falls, in one second of time, toward the sun is about .12144+ of an inch," the moon toward the sun .12084 of an inch, and the moon toward the earth .05386 of an inch. The expression "falling toward the sun" evidently means "falling from the tangent;" any other meaning is false and absurd. With the correctness of these numbers I have nothing to do. Consider them correct; then at the end of a second the earth and moon will be farther apart than they were at the beginning. Here is the proof:

In the accompanying figure let M be the place of the moon at opposition, E, that of the earth, and S the sun; A, the place of the moon at the end of a second; B, that of the earth at the same instant. Then, since the moon at opposition moves in a second about two-thirds of a mile farther than the earth, the curve MA is longer than EB, and A is farther to the right than B, and the moon at A is below the point C by .0538 of an inch: the quantity being ascertained by supposing the earth to stand fast, while the moon moves forward with the difference of their motions. On this there can be no disagreement. The distance CA is about two-thirds of a mile. *But if A is below the tangent .12084 of an inch, and B .12144 of an inch below its tangent, then B is farther from A than when the bodies were at M and E respectively.* When the earth is at B it is at the same distance from the sun as it was at E—i. e., ES and BS are

equal, and the earth must fall below the tangent .12144 in order to keep its proper distance. The same is true of the moon: in going from *C* to *A* it falls below the tangent at *C* .0538 of an inch, and then is at the same distance from *B* as it was at *C*—i. e., *B C* and *B A* are equal. Prof. Schneider's way of combining these numbers is unique. It is as if the moon had dropped toward the sun first .12084 of an inch, then .05386, while the earth had dropped toward the sun only .12144 of an inch. But Nature does not proceed in that way. The .05386 is a part of .12084, as the figure plainly shows. The .05386 is the moon's distance at *A* below the dotted line drawn from *C*, and .12084 is the moon's distance at *A* below the tangent drawn from *M*. It is easy to see that the latter includes the former. In the interest of science allow me to protest against such theories and such mathematics.

It is eminently right that we all should be earnest seekers of the truth, and it may not be out of place to suggest that the search should be diligently prosecuted *till the truth is found*, after which there will be ample time for its publication.

R. W. McFARLAND,
Professor of Mathematics and Civil Engineering, Ohio Agricultural and Mechanical College.

COLUMBUS, OHIO, *November* 24, 1877.

We can give no more space to this controversy.—ED.

THE QUESTION OF REST FOR WOMAN.

To the Editor of the Popular Science Monthly.

SIR: May I be permitted to point out certain passages in the kind and careful review of my essay on the "Question of Rest," just published in your valuable journal, in which it seems to me that the reviewer has misunderstood the drift of the statements he criticises? Accepting entirely the general criticism on "the defects due to hasty preparation," I am yet loath that this haste should be made to appear to have had a wider influence than is really the case.

On page 242 the reviewer observes that the "author traced this result—painful menstruation—to a want of occupation; while we should explain the lack of occupation by the incapacity resulting from the periodical pain." I believe the essay is guiltless of such an absurdity in physiological reasoning as an attempt to trace pain *directly* to a negative circumstance, which could only have an influence through the medium of various physiological conditions more or less directly associated with it, and hence induced by it. The inference drawn by the reviewer from the statistics is certainly incorrect, for the "unoccupied persons" referred to were so because their fortune rendered paid labor unnecessary, and for this reason it had not been undertaken. The cases where work, once begun, had been forcibly interrupted by an acquired habit of menstrual suffering are contained in the tables of painful cases.

The reviewer, page 242, second column, says that the essay admits "that, in regard to rest, the above data do not suffice to inform us of its influence," and goes on to conclude therefore that, "so far as the main theme of the book is concerned, the author leaves the question of rest in just the condition in which she found it." The statement quoted from the essay loses its real meaning by its abbreviation. It is not asserted that the data from the tables throw no light on the "question of rest," but only that from them we can have no means of deciding how far those women who acquired the habit of menstrual pain might have escaped it, had they from the beginning "rested" during menstruation, since in no case was rest found to be taken until it had become unavoidable. But the fact that so

large a percentage of women, even in the "upper" classes, are shown never to feel the need of rest at this period; the fact that in so large a proportion of those who suffer the suffering dates from the first menstruation, and hence precedes the habits of occupation sometimes supposed to induce it; the fact that in no case did rest alone succeed in averting pain or in curing its cause, and hence proved anything but the "panacea" the reviewer supposes it to be (page 244)—these facts appear plainly on the tables of the essay, and are certainly of importance in regard to the question at issue.

For the reason already surmised it may be that the reviewer has failed to see that the third section of the essay, which he describes as "containing a review of the various theories of menstruation," is devoted not to summarizing these, but to criticising them; and that an effort is made to replace one of the famous current doctrines of menstruation by another, substantially in agreement with those universally held prior to the writings of Bischoff and Pouchet and Raciborski, but claiming to contain some original details and suggestions for a new line of experiment. This effort is, to the intention of the author, the main subject-matter of the essay. That the reviewer has either overlooked this, or its bearing on the conclusions, or has not deemed it so worthy of notice as lesser details, is shown by his remark that the "experiments" were made "before, after, and during ovulation" (page 243), whereas the essay has ranged itself upon the side of those more modern thinkers whose researches are tending to reject the famous ovulation theory.

The reviewer further criticises the essay for a "strained meaning put upon the word rhythmic," and for confounding "reproduction with the conditions essential to reproduction" (page 243). It is true that a philosophical conception of causation compels us to regard every phenomenon as the result of a chain of sequences, and thus every intermittent phenomenon recurring at regular periods as the result of a rhythmic chain of sequences; and thus, in one sense, there can be no antagonism between "periodical" and "rhythmic." But the essay was compelled to consider not only facts in themselves, but certain popular preoccupations about those facts, and especially in regard to the intermittence of the menstrual hæmorrhage. The aim of the essay has been to show that this phenomenon is only one of a chain succeeding each other as continuously as do those involved in the processes of digestion, a detail of a rhythmic movement accomplished *in* the organism, and not—as much popular belief goes—a periodical accident happening *to* it. Again, it is true that in the essay the term "reproduction" is used as equivalent for the process by which material is accumulated in the parent organism for the function of reproduction. This restriction is justified by examples of the eminent biologists who, studying reproduction in its most general and abstract aspect, consider the whole process as a form of nutrition. (I may mention, as one example out of many, the lectures of Claude Bernard, published in the "Revue des Cours Scientifiques" for 1874.) For all those classes of animals in whom the conjugation of reproductive cells is effected externally to the parent organisms, it is evident that the influence of reproduction upon those organisms terminates with the formation of the reproductive cells and the accumulation of the material required for their nutrition. Hence, philosophically speaking, the most general view of reproduction coincides exclusively with this nutritive process—its type is discoverable in vegetable organisms, and the varying phenomena of animal life involved in the conjugation of reproductive cells may be considered apart. For its special purposes the essay was doubly justified in using the term "reproduction" in the sense thus defined.

It is because the essay was exclusively concerned with menstruation that "the derangements due to matrimony receive no attention," although the reviewer, in the preceding rather singularly-worded sentence, implies that they should.

In the same sentence the reviewer declares that the "motive of the book [is] to demonstrate woman's capacity for continuous work during certain periods." The only "motive" of the book was the desire to inquire *in what way* the relations of the female nutrition to the cost of reproduction might be theoretically expected to modify the capacity for exertion of the female nervo-muscular system. The reviewer is certainly in error in saying that the author "does not inform us whether ill-arrangement of work has reference to time or not;" for many pages of the essay are devoted to showing—at least in the opinion of the author—that the question of time *is* of great importance in regard to the nervo-muscular energies of women, but *not time in regard to the period of the menstrual hæmorrhages.* Morbid conditions, entailed with other diseases of civilization, may compel reference to such time; but the real necessity lies much deeper, and (theoretically) should compel more frequent intermittences in exertion, in order, roughly speaking, to allow of the accumulation in the blood of reproductive material. The essential danger of overwork in women, aside from the dangers common to both sexes, is that, if due provision be not made for "the needs of supplemental nutrition," this will be formed at the expense of the nutrition of the parent organ-

ism, which must, therefore, deteriorate. The question of rest has been entirely restated in the essay. And only by overlooking this can the reviewer be led to conclude that the "author is reasoning against her convictions;" because, having admitted that excessive work may become a cause of menstrual pain, it is nevertheless insisted upon that there is nothing in the nature of *menstruation* to imply the necessity for rest; but that the connection between overwork and menstruul suffering is more recondite than has generally been perceived.

The closing sentence of the essay, referring to the large percentage of women shown to be real sufferers at menstruation, observes that, wherever such women are engaged in industrial or other pursuits under an employer, humanity would dictate that as much rest be afforded as practicable during the period of suffering. It is difficult, therefore, to understand where the reviewer finds the recommendation for women to continue to work under the "lash of necessity or duty," if they can help it (page 244). Pain is certainly, as the reviewer says, "the ideal curse of humanity," but the world is much too far from an ideal condition to render avoidance of pain a very practicable matter in the immense majority of cases.

On page 243 the reviewer curiously misinterprets a technical statement made in the essay. It is there asserted that pain depends on an "imperfect power of resistance in the nerve-centres," an assertion which is merely the special application of a general truism in physiology. The torments suffered by dyspeptics offer a familiar illustration of the manner in which a normally painless process may become a constantly-recurring source of irritation. But no one would say, as does the reviewer, in regard to the sentence quoted from the essay, that "this presupposes an inherent tendency to pain in all human beings during this act, its expression depending on the power of repression" (page 243).

Finally, I would beg leave to say that the hope of "closing the discussion and furnishing an authoritative canon to measure the value of the question" was far beyond the ambition of the writer of the essay. The difficulty on the practical side is not "the innate delicacy of the sex in arms against the statistician" (page 241), but the difficulty common to all biological investigations upon organisms subjected to complex conditions. Every one knows that no pure experiment is possible unless all conditions are eliminated except the one whose influence is to be estimated. The difficulties in the way exactly resemble (for instance) those besetting Dr. Bowditch's recent important investigation concerning the influence of damp soils in the etiology of consumption. Although the statistics presented in the essay are, unfortunately, much smaller than is desirable, yet it is fair to add that they are the most extensive published up to this time on the subject, with the exception of those of Brierre de Boismont, and quoted in the essay. Since the addition of his results to those of the essay does not in any way conflict with the conclusions of the latter, I think it may be doubted whether more extensive *general* statistics would throw any further light on the subject. To be of value, further data must offer definite points of comparison in regard to the working and luxurious classes of society, since it is a matter of common observation, not yet submitted to strict analysis, that the liability to menstrual suffering increases in proportion as we recede from the former class (at least when it is composed of peasantry) and approach the latter. The conclusion (provisional to more exact investigation) is certainly that the menstrual disorder is not inherent in the process, or in habits of exertion during the menstrual period, being, on the whole, less in those who work than in those who do not work; but that this suffering is ultimately traceable to modifications of the entire female organism imposed by one or more of the influences of a complex civilization, many of which are confessedly pernicious. It has been the modest aim of the essay to trace out some of these modifications, and indicate in what way they might be counteracted.

MARY PUTNAM-JACOBI.

"OPEN AIR AND HEALTH."

To the Editor of the Popular Science Monthly.

I TRUST you will not think me too intrusive by a comment which I desire to make on the article in the December issue of THE POPULAR SCIENCE MONTHLY, on "Open Air and Health." I do this because I am *very solicitous* that your journal will only inculcate truth, such as we are able to know by the best heads and methods. I am of opinion that the article alluded to has a private end to boost, "a movement-cure institute," perhaps, and I am fortified in this by the false points of the essay. For instance, on page 221 it is said, "The lungs, like all mucous surfaces, secrete mucus," etc. It is needless to say that the lungs proper do not consist of mucous surface. This may, however, be a translator's stumble. But the same cannot be supposed of the following, page 223: "In the city night-air is always wholesomer than day-air, being both purer and stiller." How stillness makes it wholesome I am unable to conceive; indeed, with sewers, cesspools, and the filth of a thousand points, stillness is the most favorable for poisonous concentration, slowly diffused throughout

the ambient air by the chemical law of gaseous diffusion. Does any one suppose that, amid sources of contamination, stagnant water would be purer than running? Had Dr. Niemeyer used his nose, or attended to its monitions in his midnight ramblings among the sick, he could never have penned such an erroneous sentence. Only solicitation that your journal shall occupy the highest grounds in all its selections animates this criticism from my pen.

J. R. BLACK.

NEWARK, OHIO, *December* 22, 1877.

"THE LAW OF CONTINUITY."

To the Editor of the Popular Science Monthly.

IN the interest of scientific accuracy, I would call attention to one or two statements in the article on "The Law of Continuity," in your November number, which are either greatly strained or positively erroneous.

The author of the article in question says, speaking of sulphuric acid and water, "In all possible percentages do these liquids *chemically combine*, and this is at variance with the generally obeyed law of definite proportions" (page 32 — the italics are mine). This is a very loose use of language, as may be easily demonstrated by a comparison of this passage with the statement of the fact by any scientific authority. For example, Fownes ("Manual of Chemistry," eleventh edition, p. 203) says: "The most concentrated sulphuric acid, or *oil of vitriol*, as it is often called, is a definite combination of 40 parts sulphuric oxide and 9 parts water. . . . Oil of vitriol is not the only hydrate of sulphuric oxide; three others are known to exist. When the fuming oil of vitriol of Nordhausen is exposed to a low temperature, a white crystalline substance separates, which is a hydrate containing half as much water as the common liquid acid. Further, a mixture of 98 parts of strong liquid acid and 18 parts of water, $2H_2OSO_3$, or $H_2SO_4H_2O$, congeals and remains solid even at 7.2° C. (45° Fahr.)," etc. There is, then, in the case of sulphuric acid and water, at least, a clear enough distinction between mechanical mixture and chemical combination, although Mr. Iles quite loses sight of it.

Then, again, he says (p. 30), "Science is unable to give us any metal but gold in a translucent state." The inability does not lie with "science." It has long been known that silver may, by chemical means, be obtained in a translucent film. And likewise platinum, aluminum, bismuth, copper, lead, iron, nickel, cobalt, palladium, zinc, cadmium, magnesium, and other metals, have been procured in a layer so thin as to be transparent (Wright, *American Journal of Science and Arts*, No. 73, January, 1877).[1]

LAUNCELOT W. ANDREWS.

SPRINGFIELD, MASS., *November* 8, 1877.

EDITOR'S TABLE.

COOK AND HIS "BIOLOGY."

THE Rev. Joseph Cook seems to have attained the position of an accepted champion of orthodoxy in its conflict with the science of the time, and as such must have a degree of attention to which he is not otherwise entitled. In the delivery of the lectures which compose his volume on biology, he was listened to, we are told, by large audiences of cultivated and scholarly men, who applauded him enthusiastically; while the book has been highly praised by eminent theologians and numerous newspapers, and has had a brisk and extensive sale. Yet we observe that the tide of encomium is perceptibly falling, and shrewd orthodox people are beginning to see that they cannot too quickly relieve themselves of responsibility in regard to his work. In an able review, in the January *New-Englander*, the scientific charlatanry of Mr. Cook's book is thoroughly exposed; its taste and rhetoric are pronounced "execrable," and the writer closes by saying that "this production is not one for orthodoxy to be proud of, and that it is best to declare this opinion plainly and promptly."

Nevertheless there is a startling significance in the fact that such a work could have received from an intelligent Christian community the measure of commendation that has been accorded

[1] It is but fair to say that the article in question was written and in the hands of the editor six months before Prof. Wright's researches were published.—ED.

to it. Any infidel book that had gone as far toward extirpating the miraculous from Christianity would have been pitched into the flames as blasphemous by every devout believer. The grand central miracle of Christianity, among all orthodox people held as a belief too sacred to be approached in a rationalistic way, is the supernatural genesis of its divine founder. And yet this reverend biologist of Boston attacks the subject with the microscope, quotes Haeckel to prove that bees multiply without the intervention of the male, claims that this principle "extends to the higher forms of life," and, "in the presence of Almighty God," suggests that Christ may have originated in the same natural way. He even thinks that if this fact of parthenogenesis in natural history had been sufficiently known it would have been potent in saving men from skepticism by relieving their perplexities respecting the parentage of the Saviour, and he cites a conspicuous illustration, as follows: "When a great soul like the tender spirit of our sainted Lincoln, in his early days, with little knowledge, but with great thoughtfulness, was troubled with this difficulty, and almost thrown into infidelity by not knowing that the law that there must be two parents is not universal, I am willing to allude, even in such a presence as this, to the latest science concerning miraculous conception." "The latest science!" Perhaps Mr. Lincoln, after all, with his "little knowledge," was not so ignorant as our biological lecturer, who seems not to know that the Swiss naturalist, Bonnet, had established asexual multiplication, in the case of plant-lice, three-quarters of a century before Lincoln was born.

We must not, however, expect too much, and are glad of any earnest scientific discussion in theological quarters. A book from a clergyman, bearing the title of "Biology," has not only the commendable merit of novelty, but it is an encouraging sign of the times, and a promising precedent for the future. Nor should we be too exacting in regard to the quality of first efforts, as theology is certainly not the best preparation for biology. Yet when a Christian preacher takes up the science, and we allow for the imperfections of treatment to be naturally expected of an inquirer in an unfamiliar region, we are still entitled to demand candor, fairness, and conscientious painstaking honesty of statement. Though we may not get intelligence, we ought, at least, to have common morality. We propose briefly to test Mr. Cook's book by this very moderate standard, and will take his first position as a sample. We shall thus be enabled not only to get a good measure of the claims of his work, but to correct a popular misapprehension of some consequence.

It is generally known that Prof. Huxley, a few years ago, examined a substance brought up from the sea-bottom, and announced it as a newly-discovered form of protoplasm, to which he gave the name of *Bathybius;* and it is currently supposed that he afterward abandoned this view as erroneous. Mr. Cook begins his biology with an account of this matter. Its first sentence is as follows: "In 1868 Prof. Huxley, in an elaborate paper in the *Microscopical Journal*, announced his belief that the gelatinous substance found in the ooze of the beds of the deep seas is a sheet of living matter, extending around the globe." We have carefully read that article, and have found no such statement, and nothing equivalent to it, there. Dr. A. P. Peabody, of Harvard University, reviewing the book we are now considering, says that "Mr. Cook's reasonings are based in no instance on his own statement of physical or scientific truth or fact; but always on the expressly-quoted words of writers of universally admitted authority." This is contradicted by the very first utterance of Mr. Cook, in which

Prof. Huxley's words are neither "expressly quoted" nor quoted at all, and in which the substance is not to be found in the article cited.

The second paragraph of the book opens thus: "To this amazingly strategic and haughtily-trumpeted substance found at the lowest bottoms of the oceans, Huxley gave the scientific name *Bathybius*, from two Greek words meaning *deep* and *sea*, and assumed that it was in the past, and would be in the future, the progenitor of all the life on the planet." It is not true that, in the article cited by Mr. Cook, Prof. Huxley made any such assumption as is alleged, any more than it is true that the word Bathybius has the derivation here assigned to it. This characterization of the announcement of Bathybius is simply a slanderous misrepresentation. That Mr. Cook intended it to apply to Huxley is obvious from the connection, and is proved by the fact that on page 69 he again refers to it as "the haughty claim of Huxley." Nothing could be more false, as we shall presently show, than the impression conveyed by this language.

On the third page we are told that "Dr. Carpenter rejected Huxley's testimony on this matter of fact," but where, or in what form, he has done so is not mentioned. The statement is entirely improbable, as Dr. Carpenter had himself observed the living Bathybius dredged up on the expedition of the Porcupine, samples of which he furnished to Huxley; while so late as 1875 he speaks in his work on the microscope "of these indefinite expansions of protoplasmic substance, which there is much reason to regard as generally spread over the deep-sea bed."

Having introduced Bathybius to the attention of his auditors, in the manner here indicated, Mr. Cook announced to them, with due rhetorical flourish, that it is now nothing but an exploded myth. We shall be better able to judge of the truthfulness, both of his former statements and of this assertion, by briefly glancing at the history of the substance.

The paper of 1868 here referred to is entitled "On some Organisms living at Great Depths in the North Atlantic Ocean." In the first part of this article he referred to a report, which he had himself drawn up, concerning the sticky mud obtained by Captain Dayman in sounding the North Atlantic in 1857; the report of Prof. Huxley being published in 1858. In his observations upon this mud he discovered some curious little microscopic bodies, which at first suggested an organic origin, but which Prof. Huxley concluded were not of this character. The language in the original report is as follows: "I find in almost all these deposits a multitude of very curious rounded bodies, to all appearance consisting of several concentric layers surrounding a minute, clear centre, and looking, at first sight, somewhat like single cells of the plant *protococcus;* as these bodies, however, are rapidly and completely dissolved by dilute acids, they cannot be organic, and I will, for convenience' sake, simply call them coccoliths."

Some observations made by Dr. Wallich and Mr. Sorby led them to think that Prof. Huxley had been mistaken in the conclusion here given, and that the objects which he supposed to be of a mineral nature were really of organic origin. Prof. Huxley was then led to reconsider the subject, of which he made a prolonged study with higher microscopic powers, and the result was that he came to the same conclusion as the observers referred to, that the minute microscopic objects belonged to the lowest forms of the living world. Certain minute albuminous or protoplasmic bodies of the very lowest type had been discovered by Prof. Haeckel, and named moners, and it was Prof. Huxley's opinion that the minute objects he had been studying from the sea-slime belong to this class. We quote the passages from the article in

the *Microscopical Journal* of 1868, in which his conclusions are stated: "Such, so far as I have been able to determine them, are the facts of structure to be observed in the gelatinous matter of the Atlantic mud, and in the coccoliths and coccospheres. I have hitherto said nothing about their meaning, as, in an inquiry so difficult and fraught with interest as this, it seems to be in the highest degree important to keep the questions of fact and the questions of interpretation well apart."

Again: "I conceive that the granule-heaps and the transparent gelatinous matter, in which they are imbedded, represent masses of protoplasm. Take away the cysts which characterize the *radiolaria*, and the dead *spherozoum* would very nearly resemble one of the masses of this deep-sea *Urschleim*, which must, I think, be regarded as a new form of those simple animated beings which have recently been so well described by Haeckel, in his 'Monographie der Moneren.' I propose to confer upon this new monera the generic name of *Bathybius*, and to call it after the eminent Professor of Zoölogy in the University of Jena, *B. Haeckelii*."

This modest and cautious statement is the whole of the announcement of Bathybius. It is made by a scientific man in the true spirit of science, and when the Rev. Mr. Cook charges Huxley with "haughtiness" in regard to it, his statement has no value except as an exemplification of the trustworthiness of his book. What the nature of the evidence was for the existence of this protoplasmic substance at the bottom of the sea will appear from the following statements:

Those eminent zoölogists, Sir Wyville Thomson and Dr. William B. Carpenter, while engaged in a deep-sea exploring expedition in the North Atlantic with the war-ship Porcupine, had abundant opportunity to examine the ooze of the ocean-bed, and they write in the *Magazine of Natural History* (1869), "This ooze was actually living; it collected in lumps, as though albumen had been mixed with it; and under the microscope the sticky mass was seen to be living sarcode." The protoplasmic character of this simplest-formed material of low animal life was still further attested by Sir Wyville Thomson in his "Depths of the Sea" (page 410, second edition, 1874): "If a little of the mud, in which this viscid condition is most marked, be placed in a drop of sea-water under the microscope, we can usually see, after a time, an irregular network of matter resembling white of egg, distinguishable by its maintaining its outline and not mixing with the water. This network may be seen gradually altering in form, and entangled granules and foreign bodies change their relative positions. The gelatinous matter is, therefore, capable of a certain amount of movement, and *there can be no doubt* that it manifests the phenomena of a very simple form of life."

Dr. Emil Bessels, who accompanied the expedition of the Polaris, writes to a German journal of natural history: "I found in Smith Sound, at the depth of ninety-two fathoms, great masses of free, undifferentiated homogeneous protoplasm," which he names Protobathybius. He adds: "I would simply say, in this place, that these masses consisted of pure protoplasm, in which calcareous particles occurred only by accident. They appeared to be very sticky, mesh-like structures, with perfect amœboid movements; they took up particles of carmine and other foreign substances, and there was active motion of the nuclei."

And now, to nullify the effect of such direct, positive, and concurrent observations made and verified, again and again, by experienced men, what have we? Only this: the ship Challenger started around the world to dredge the sea-bottom, and its observers sought Bathybius and did not find

it. But this negative evidence is worth nothing, except to correct the error of those who supposed Bathybius to be universally distributed over the sea-bottom. It does not touch the question of its existence. Sir Wyville Thomson, in charge of the Challenger expedition, wrote to Huxley that they had not only failed to discover Bathybius, but that it was seriously suspected that the thing to which the name had been given is little more than sulphate of lime, precipitated in a flocculent state from sea-water by spirits of wine. Prof. Huxley immediately communicated this report of Sir Wyville Thomson to *Nature*,[1] and he adds: "Prof. Thomson speaks very guardedly, and does not consider the fate of Bathybius to be as yet absolutely decided. But, since I am mainly responsible for the mistake, if it be one, of introducing this singular substance into the list of living things, I think I shall err on the right side in attaching even greater weight than he does to the view which he suggests."

Let it be remembered that the sole question here is as to the interpretation to be given to observations on sea-slime. But such observations had been made elsewhere over and over again, in many places, and by numerous microscopists. The flocculent gypsum precipitate in sea-water had been, moreover, known to everybody who had preserved marine animals in alcohol. It was, of course, a proper question to raise, how far such an effect might not be mistaken for reactions of protoplasm; but to suppose that anything was here finally decided is simply preposterous—much more so, that all previous observations on sea-bottom protoplasm were proved worthless. The "suspicion" was quite legitimate, but it was only a suspicion, and was offered as nothing more. Huxley expressed himself simply in the terms of courtesy that were suitable to the occasion. Sir Wyville Thomson spoke cautiously; and Huxley accorded to his statement all possible weight. If he had been disposed to contest the matter, this would not have been the appropriate time, as his object was nothing more than to communicate to the public what had been sent to him for that purpose. Mr. Cook makes a great ado about Huxley's "recantation," but, so far from recanting, he does not even admit that he had been mistaken. He gave Sir Wyville Thomson the fullest benefit of his doubt, and there left the matter for further investigation. The Rev. Mr. Cook, however, returns to the subject in his third lecture, and edifies his intelligent Boston audience by closing with the following whoop: "That Bathybius has been discovered in 1875 by the ship Challenger, to be—hear O heavens! and give ear, O earth!—sulphate of lime. (Applause.)"

We may here note the contrast between the theological biology which so evoked the plaudits of Boston orthodoxy and biology of the common scientific kind. It was evidently a part of Mr. Cook's polemical tactics to open his course of lectures by a sensational dash that should make a breach in the scientific ranks which it was the object of the "Monday lectureship" to rout, and for this purpose nothing could be more telling than to discredit Prof. Huxley at the outset. So much had been said, and so little was really known, about "Huxley's Bathybius," that this seemed to offer the most vulnerable point of attack. But had Mr. Cook not been talking to people who know nothing about the difficulties of arriving at the truths of Nature—nothing of the inexorable disciplines of science—and who pride themselves on never giving up a dogma once professed; had he not, in short, been catering to the "closed, dogmatic" mind of a locality proverbial for pride of opinion, his effort would hardly have been greeted with the reported applause. Had Prof. Huxley been in error, would it not

[1] *See* POPULAR SCIENCE MONTHLY, October, 1877, p. 648.

have been to his credit to retract it? How else have the truths of science and the laws of Nature been established, except by righting wrong conclusions, committing mistakes and then correcting them, and escaping from erroneous opinions by showing them to be false? This is the essential method, and the constant work of science, and it is exactly here that it becomes the antagonist of that method which tacitly or openly affirms infallibility of belief, and holds it to be a reproach and a disgrace to acknowledge that one has ever been mistaken. If there had been no revolt against this spirit, we should never have had any such thing as science.

We dismiss this much-lauded book with one more illustration of its quality. Having got through the sixth lecture, still devoted to his main thesis—the deduction of immortality from protoplasm—Mr. Cook pointed the moral of the occasion in the following characteristic way. He said: "Here is the last white and mottled bird that flew to us out of the tall *Tribune* tower; and softly folded under its wing are these words concerning Darwin, from Thomas Carlyle, at his own fireside in London." He then read the sensational story that has for some time past been going the rounds of the newspapers about Carlyle's declaring the Darwins to be "atheists all," with some stupid rant about the gospel of dirt, and men coming from monkeys and frog-spawn, and winding up with his standing on the brink of eternity and reviving the lessons of his catechism. Mr. Cook then calls impressively upon "Boston, and the New England colleges, and all tender and thoughtful souls, to listen to Thomas Carlyle as he stands on the brink of eternity."

Now, we never doubted that this representation, so greedily caught by press and pulpit, was essentially a lie. Not that Mr. Carlyle may not have included Darwinism among the multitudinous modern things that he has been wont to rave about, but this circumstantial statement had all the internal evidence of fabrication and falsehood. Mr. Cook says it was an "extract from a letter from Carlyle, published in Scotland, and quoted in the London *Times*." Yet long before Mr. Cook published his book the story was contradicted in that journal "on the best authority." The "Monday lectureship" was, however, "abreast of the times" only for the purpose of *circulating* the scandal. The following note, printed in the London *Times* of January 20, 1877, neither appears in the "Biology," nor, so far as we have observed, has appeared in the American newspapers which gave such swift passport to the first statement:

MR. CARLYLE ON DARWINISM.

"L." writes: "Allow me to state on the best authority that the letter about Darwin and his doctrines, which was quoted in the *Times* on the 17th inst. from the *Ardrossan and Saltcoats Herald*, was not written by him."

This should have been quite sufficient to stop the story, but some people are incredulous when dirty gossip is to be checked, and demand responsible names. It may, therefore, be proper to say that we happen to have been informed by Herbert Spencer that the note to the *Times* was communicated by Mrs. Lecky, the wife of the historian, and that she stated to Mr. Spencer before its publication that, while Mr. Carlyle, in pursuance of his practice of never noticing misstatements, would not contradict it himself, he had authorized her to make the contradiction. It thus appears that a party in England forges a libelous letter, in the interest of orthodoxy, which is made to do duty in New England in the same interest, while the solemn adjuration to listen to the libelous forgery is responded to with the usual "applause."

It is the frequent custom of clergymen to characterize much of the work of modern scientific thinkers as "pseudo-

science," "sham science," and "science falsely so called;" but truly does the Rev. Joseph Cook's "Biology" answer to their ideal of a genuine thing? And must we not conclude, from the way they praise it, that our orthodox friends are rather hard pressed for championship?

OPENING OF THE MUSEUM.

It is not often that we get so much momentous thought in so narrow a compass as was furnished by Professors Eliot and Marsh, in their addresses at the recent opening of the American Museum of Natural History in this city. President Eliot, of Harvard, summed up in a few weighty words the grandest characteristic of modern science, and pointed out two of its most profound and far-reaching results. The completion of a new Museum of Natural History seemed the fitting occasion to recognize that science has given a kind of new birth to the human mind—a new method and spirit of thought in essential contrast with the old dogmatic dispensation. This grand result, not yet very widely recognized, and where recognized not yet very courageously avowed, nevertheless many times outweighs in import all the material conquests of scientific research. The doctrine of heredity, in its comprehensive application to man and social institutions, and the doctrine of continuity in Nature, and the slow unfolding of higher and better conditions, are credited with an exalted place among the later achievements of the scientific mind. We cannot forbear expressing our gratification at so unqualified an indorsement from such a distinguished source, and on such a conspicuous occasion, of ideas which THE POPULAR SCIENCE MONTHLY has earnestly sought to diffuse ever since it was started.

Prof. Marsh made a telling appeal for the encouragement of original scientific work. He called attention to the danger that such museums are liable to degenerate into mere shows, and pointed out that their higher service is to facilitate, encourage, and keep alive, that spirit of investigation by which alone knowledge is developed and perfected. His suggestions were pertinent and timely, and it is to be hoped they will be heeded, and that due provision will be made for students who wish to engage in the promotion of original work.

LITERARY NOTICES.

ELEMENTS OF GEOLOGY: A TEXT-BOOK FOR COLLEGES AND FOR THE GENERAL READER. By JOSEPH LE CONTE, Professor of Geology in the University of California. 903 Illustrations. New York: D. Appleton & Co. Pp. 588. Price, $4.

SIR JOHN HERSCHEL has somewhere remarked that, in the vastness and sublimity of its leading ideas, geology is the rival of astronomy; for, as the latter has to deal with immeasurable space, the former opens the conception of immeasurable time. There is a splendor about the science of celestial phenomena that is, of course, unrivaled; but there is a deep fascination about the history of the development of our planet that comes from the immensity of the periods involved, the stupendous scale of the changes that have taken place, and the practical results derived from our knowledge of the constitution of the earth's crust.

These noble elements of the science must ever give geology a powerful claim upon the attention of cultivated people, and they have gained for it, and will secure to it, a leading place in all our higher courses of study. But scientific education is yet in its infancy, and its incorporation with the traditional culture has thus far been very much a matter of accident, caprice, or indifference. Geology has perhaps suffered more than any other science from the unsettled state of the relations between scientific and literary culture. Not that the subject has been neglected, but it has been treated without judicious and adequate preparation. We have had admirable elaborate works for the information of professional geologists and the training of students who design to become geologists; and we have had excellent

rudimentary books for introducing beginners to the subject and for use in ordinary schools. But a good college text-book of geology has hitherto been wanting. There has been no American work for high-class institutions which treats the subject so as to meet the requirements of intelligent and scholarly people, who yet do not expect to become independent cultivators of geological science. This manifest gap has now been filled by the publication of the work before us, and a careful examination of the volume convinces us that it has been executed with great judgment with reference to the present needs of higher education. In his preface Prof. Le Conte thus states the purpose he had in view in writing the work: "I have attempted to realize what I conceive to be comprised in the word *elements* as contradistinguished from *manual*. I have attempted to give a really scientific presentation of all the departments of the wide field of geology, at the same time avoiding too great multiplication of detail. I have desired to make a work which shall be both interesting and profitable to the intelligent general reader, and at the same time a suitable text-book for the higher classes of our colleges. In the selection of material and mode of presentation, I have been guided by long experience as to what it is possible to make interesting to a class of young men, somewhat advanced in general culture and eager for knowledge, but not expecting to become special geologists. In a word, I have tried to give such knowledge as every thoroughly cultured man ought to have, and at the same time is a suitable foundation for the further prosecution of the subject to those who so desire. The work is the substance of a course of lectures to a senior class, organized, compacted, and disencumbered of too much detail by representation for many successive years, and now for the first time reduced to writing."

But, besides preparing a comprehensive text-book, suited to present demands, which was the author's main design, he has also given us a volume of great value as an exposition of the subject, thoroughly up to date. It is well known that geology is one of the most rapidly progressive of the sciences, but in recent years its advances have been very remarkable. Not only are its facts multiplying at an unprecedented rate, through the labors of the increasing multitude of geological observers in all lands, but its progress is to a still greater degree signalized by the light thrown upon it by various other sciences, and by the working out of fundamental principles by which its multitudinous details are organized into more perfect method. The law of evolution is now the key to geology. A vague principle of progress has long been obscurely recognized in geological phenomena, but that principle has now been brought out, amplified, formulated, and established, as the all-interpreting law that has governed the unfolding of the globe. Much remains to be done, no doubt, in the elucidation of this grand principle, but its imperfection now becomes a measure of the imperfection of geology itself, and no presentation of that science is any longer possible which does not give prominence to the doctrine of evolution. Prof. Le Conte not only accepts it, but puts it to its proper scientific use, as his volume bears abundant witness, and as he explains in the following words from the preface: "In the historical part, I have found much more difficulty in being scientific without being tiresome, and in being interesting without being superficial and wordy. I have attempted to accomplish this difficult task by making *evolution* the central idea about which many of the facts are grouped. I have tried to keep this idea in view, as a thread running through the whole history, sometimes very slender—sometimes, indeed, invisible; but reappearing from time to time to give consistency and meaning to the history."

The examples and applications of Prof. Le Conte's work are almost entirely derived from this country, so that the treatise may be properly considered an American geology. This involves no narrowness or incompleteness; for, although science is as wide as Nature, yet the illustrations of geology are necessarily local, and an important point is gained when those are selected which will be most naturally observed by the great mass of students for whom the volume was designed. The region of the Rocky Mountains and the Western portions of the continent, as is well known, have

recently yielded the most striking and important contributions to the subject, both in dynamical and structural geology, and in the department of ancient life. Prof. Le Conte's residence in California, for the last few years, has been favorable to the cultivation of this field, of which he has fully availed himself by excursions of observations, and vacation-rambles with parties of students and graduates, through regions especially rich in geological interest. His book contains the results of these personal inquiries, and those of other observers, including the revelations of remarkable fossils by Prof. Marsh and the naturalists who have devoted themselves to paleontological exploration.

The volume is written with great clearness and with admirable judgment in respect to the proportions of space allotted to its multifarious topics. A prime object with the author has been to interest his readers, and for this purpose he has given prominence to principles and subordinated details, so that his work will prove attractive to the general reader as well as to the class-room student. It is profusely and elegantly illustrated, in a style of which the reader will be enabled to judge by referring to the article on "Geysers," in the present number of the MONTHLY, which is borrowed from the volume. This treatise is by an eminent working geologist, one who knows the subject thoroughly in its latest aspects, and we can commend it without qualification to all who desire an intelligent acquaintance with the science, as fresh, lucid, full, authentic, the result of enthusiastic study and of long experience in the art of teaching mature classes.

DETERIORATION AND RACE EDUCATION, WITH PRACTICAL APPLICATION TO THE CONDITION OF THE PEOPLE AND INDUSTRY. By SAMUEL ROYCE. New York: Printed by Edward O. Jenkins, 20 North William Street. Pp. 504. Price, $4.50.

IN this book education is considered from a broad, humanitarian point of view, and in connection with the great causes of decay and deterioration that are operating in society. The wealth of facts and materials of all kinds that the author has brought together seems to have proved somewhat embarrassing to him, as he has hardly succeeded in bringing them into close logical method. But he has collected a great deal of interesting material, interspersed with valuable observations and reflections, and the volume is pervaded by a reformatory and progressive spirit. Mr. Royce's chapter on "Classical and Scientific Education" contains much good sense, and his opinions are very decided, as the following passage illustrates: "Emerson says that he has not met in all his travels in America with half a dozen men who could read Plato profitably. This whole Greek and Latin scholarship is an imposture, the writing of miserable verses in these languages included. There is not one teacher in ten who has sufficient knowledge of these languages to derive from them a higher culture. The learned apparatus requisite for their thorough understanding requires the study of a lifetime. Must hundreds of thousands of students in the land throw away their years and opportunities for the sake of a few hundred Latin and Greek roots, which can be learned by any English student with the help of an etymological hand-book in a few weeks, if not days?"

NOTES ON LEATHER. By Lieutenant D. A. LYLE.

THESE "Notes," published by order of the Secretary of War for the use of the Ordnance Department of the U. S. Army, contain a large amount of useful and practical information concerning hides and the manufacture of leather. Sundry fraudulent practices used in tanning are pointed out, and their effects on the leather described. The author does not undertake to give judgment on the comparative merits of oak-tanned and hemlock-tanned leather; it would require an exhaustive series of experiments to decide this question ultimately.

TRANSACTIONS OF THE KANSAS ACADEMY OF SCIENCES. Topeka: Kansas Publishing-House. Vol. V. Pp. 75.

AMONG the papers published in this volume are several natural history catalogues relating to the botany and entomology of Kansas, a meteorological summary for 1876, essays on evidences of ancient forests in Kansas, on river-bluffs, the habits of prairie-dogs, the influence of food-selection upon animal life, etc.

THE A, B, C, OF FINANCE. By SIMON NEWCOMB, LL. D. New York: Harper & Brothers. Pp. 115. Price, 25 cents.

PROF. NEWCOMB is an astronomer, and of course mostly interested in the stars, but he finds time to give a portion of his attention to the affairs of his country, and he, moreover, makes a contribution where it is most needed. It is in the field of finance that the nation now needs the greatest help, and we agree with Prof. Newcomb that the popular instruction at present most urgently demanded is in the A, B, C, of financial science. In the miniature form of "Harper's Half-Hour Series" the author has brought out a succession of chapters on "Labor," "Capital," "Wages," "Value," the "Different Kinds of Money," "Public Faith," and the "Lessons of History," which are written in a clear, simple, instructive, and most convincing manner. Such nimble little pocket-books, pointedly summing up these large subjects, are wanted by the people, and are capable of doing more efficient service than larger books.

ROBINSON CRUSOE'S MONEY: OR, THE REMARKABLE FINANCIAL FORTUNES AND MISFORTUNES OF A REMOTE ISLAND COMMUNITY. By DAVID A. WELLS. New York: Harper & Brothers. Pp. 118. Price, 50 cents.

IN this small volume Mr. Wells inculcates the lessons of political economy through a sort of allegorical artifice, in which commercial and financial truths and absurdities are brought out in a dramatic way that is both amusing and instructive. Many who would not like a dry, didactic treatise on economics would be pleasantly beguiled by Mr. Wells's imaginary narration, while the characteristic illustrations, by Nast, will serve to help on both the fun and the logic of the text.

A NEW TREATISE ON STEAM-ENGINEERING, PHYSICAL PROPERTIES OF PERMANENT GASES, AND OF DIFFERENT KINDS OF VAPOR. By JOHN W. NYSTROM, C. E. New York: G. P. Putnam's Sons. Pp. 188. Price, $1.50.

THIS book consists of numerous tables, data, and information, which appear to the author to be wanting in the profession, and which have not heretofore been published. Among the topics are horse-power of steam-boilers, chimneys, combustion, properties of fuel, smoke-burning, water-gauges, safety-valves, radiation, steam-boiler explosion, strength of steam-boilers, compression and expansion of air, properties of water and steam, and various other subjects of interest to engineers. The author rejects no less than thirty-eight terms or phrases that have grown up, and come into modern use in mechanical science.

PUBLIC HEALTH REPORTS AND PAPERS. Vol. III. Presented at the Meetings of the American Public Health Association in the Years 1875–1876. New York: Hurd & Houghton. Pp. 241. Price, $4.

AMONG the most important volumes issued from our press are the reports of the American Public Health Association. They comprise papers on a variety of important topics, connected with the health of the community, by our most eminent sanitarians; and they will be generally found valuable as summing up, and stating in a clear and readable form, the results of long study and well-directed investigation. Among so excellent an array of articles as the present volume furnishes, it seems invidious to discriminate, and in especially commending the papers of Dr. Austin Flint, on "Food in its Relations to Personal and Public Health;" of Prof. Washburn, on "Expert Testimony and the Public Service of Experts;" and of Mr. Charlton Lewis, on "The Influence of Civilization on the Duration of Life," we do not for a moment imply that the other discussions of the volume, all of them on important subjects, are not of equal interest and ability. This series of reports should be found in the libraries of all who take interest in the vital subject of personal and public hygiene.

FROM Prof. C. V. Riley we have received a reprint of five papers contributed by him to the "Transactions" of the St. Louis Academy of Sciences; their titles are as follows: "Larval Characters and Habits of the Blister Beetles belonging to the Genera *Macrobasis* and *Epicauta*;" "On a Remarkable New Genus in *Meloidæ*;" "Notes on *Megathymus yuccæ*;" "Remarks on *Pronuba yuccasella*;" "Differences between *Anisopteryx pometaria* (Harr.) and *Anisopteryx æscularia* (W.-V.)."

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION FOR THE YEAR 1876. Government Printing-Office, Washington. Pp. 488.

IN addition to the report of the secretary, on the operations, expenditures, and conditions of the Institution, this volume contains the following elaborate and important papers. "Eulogy on Gay-Lussac," by M. Arago; "Biographical Sketch of Dom Pedro II., Emperor of Brazil," by Anpriso Fialho; "Kinetic Theories of Gravitation," by Wm. B. Taylor; "The Revolutions of the Crust of the Earth," by Prof. George Pilar; "Ethnology," by Otis T. Mason.

THE RELIGIOUS FEELING, A STUDY FOR FAITH. By NEWMAN SMYTH. New York: Scribner, Armstrong & Co. Pp. 171. Price, $1.25.

THIS is an earnest, and intended to be a philosophic and liberal, discussion of the modern problems of religious thought in relation to science, positivism, and Darwinian and Spencerian doctrines. It is too brief to have finished up the inquiry; but its issue is thus stated by the author: "The problem of problems, upon which the thought of our time labors, may be reduced in the last analysis to the simple alternative: is man, through whatever intermediate forms he may have descended, the son of God, or is he the unintended product of molecular forces?" It is hardly necessary to say that the writer accepts the former alternative, and vigorously belabors the school of thinkers which he charges with holding the latter opinion.

SANITARY CONDITION OF CITY AND COUNTRY HOUSES. By G. E. WARING, JR. Pp. 145. MAGNETISM OF IRON VESSELS. By F. ROGERS. New York: Van Nostrand. Pp. 126. Price, 50 cents each.

THE first of these little volumes contains two papers read by Mr. Waring at meetings of the American Health Association, together with the rather voluminous correspondence occasioned by their publication in the *American Architect*. In this correspondence some of the author's facts and conclusions are criticised by other sanitarians. Mr. Waring's replies to these strictures form a very valuable appendix to the original papers. Of the other volume named above, we need only say that it was originally prepared for a manual designed to be published by the Navy Department. The publication of the manual having been abandoned, the treatise was incorporated into Van Nostrand's "Science Series."

HOW TO USE THE MICROSCOPE. By JOHN PHIN. New York: Industrial Publication Co. Pp. 181. Price, 75 cents.

Two years ago we noticed the first edition of this little manual for beginners with the microscope, and now we have to record the appearance of a second edition, fully illustrated and greatly enlarged. Its essential character as an *elementary* treatise is, however, still rigidly preserved.

ANALES DEL MUSEO NACIONAL DE MÉXICO. México: Imprenta de C. Ramiro. Vol. I., Part I. Pp. 46. With Plate.

THIS initial number of the "Anales" is devoted mainly to Mexican archæology. The principal paper is a description, by Don Manual Orozco y Berra, of a curious cylindrical monument of stone, the Cuauhxicalli of Tizoc, supposed to be a sacrificial stone employed in human sacrifices. This monument is elaborately engraved with human figures. The second paper is by Dr. G. Mendoza, and describes an Aztec idol of Chinese type, found in a tumulus in the State of Puebla. The third and last paper is a general introduction to the "Paleontology of Mexico," by Mariano Bárcena.

PUBLICATIONS RECEIVED.

Why we Trade and How we Trade, pp. 67; The Silver Question, pp. 47, both by D. A. Wells; The Tariff Question by H. White, pp. 30. New York: Putnam's Sons. 25 cents each.

Rotation of the Earth. By W. L. Walker. New York: S. W. Green. Pp. 64.

The Kabbala, or True Science of Light. By Dr. S. Pancoast. Philadelphia: J. M. Stoddart & Co. Pp. 312. $2.

Transcendentalism. By J. Cook. Boston: J. R. Osgood & Co. Pp. 305. $1.50.

Manual of Heating and Ventilation. By F. Schumann, C. E. New York: Van Nostrand. Pp. 89. $1.50.

Daily Bulletin of the Signal Service, United States Army, for September, 1874.

What was He? or, Jesus in the Light of the Nineteenth Century. By W. Denton. Wellesley, Mass.: The author. Pp. 259. Paper, $1; cloth, $1.25.

The Spiritual Aspect Nature presents. By J. Wilmshurst. Boston: Colby & Rich. Pp. 151. 35 cents.

The Silver Country of the Southwest. By A.

D. Anderson. New York: Putnam's Sons. Pp. 221. $1.75.

Mechanics of Ventilation. By G. W. Rafter, C. E. New York: Van Nostrand. Pp. 96. 50 cents.

Golden Songs of Great Poets. New York: Sarah H. Leggett. Profusely illustrated. $5.

The Action of Medicines. By Dr. I. Ott. Philadelphia: Lindsay & Blakiston. Pp. 168. $2.

Notes from Chemical Laboratory of Johns Hopkins University. Nos. 4–8.

Mansill's Almanac of Planetary Meteorology, 1878. Rock Island, Ill.: R. Crampton. Pp. 60. 50 cents.

Ueber die als echt nachweisbaren Assonanzen der Chanson de Roland. Von A. Rambeau. Pp. 38.

Are the Indians dying out? Washington: Government Printing-Office. Pp. 42.

Mound-making Ants of the Alleghenies. By Rev. H. C. McCook. Philadelphia: Sold by J. A. Black. With Plates. Pp. 43. 75 cents.

Relation of Moisture in Air to Health. By R. Briggs. Philadelphia: W. P. Kildare print. Pp. 33.

Papers read before the Pi Eta Scientific Society. Troy: The Society. Pp. 40.

The Preliminary Arctic Expedition. Washington: Beresford print. Pp. 32.

Report of the Asylum at Walnut Hill, Hartford, Conn. Pp. 20.

The Heavenly Bodies; How they move. By D. McDonald. Montreal: *Gazette* print. Pp. 45.

Immortality. By W. Bross. Chicago: Jansen, McClurg & Co. Pp. 8.

Direct Process of making Iron and Steel. By C. M. Du Puy, C. E. Philadelphia: W. P. Kildare print. Pp. 12.

Medical Jurisprudence of Insanity. By Dr. H. Howard. Montreal: *Gazette* print. Pp. 13.

Every Saturday (weekly). Buffalo: D. Welch. Pp. 12.

A Decimal Gauge for Sheet-Metal and Wire. By R. Briggs, C. E. Philadelphia: W. P. Kildare print. Pp. 13.

POPULAR MISCELLANY.

Meyer's Electrical Apparatus for Beginners.—We some time ago noticed the admirable little work on electricity by Prof. Tyndall, which grew out of a course of holiday lectures to a juvenile audience at the Royal Institution. This book, "Lessons in Electricity," is designed as a guide for beginners to go through a course of electrical experimenting. The main purpose that he had in view, in preparing this little volume, is thus stated: "I had heard doubts expressed as to the value of science-teaching in schools, and I had heard objections urged on the score of expensiveness of apparatus. Both doubts and objections would, I considered, be most practically met by showing what could be done in the way of discipline and instruction by experimental lessons, involving the use of apparatus so simple and inexpensive as to be within everybody's reach."

Of course there can be no experimenting without the necessary instruments, and, if the work is to be pursued so as to yield its proper benefits, the apparatus must be sufficient to cover a definite field of study. Prof. Tyndall has marked this out in his little volume, and given figures of the various articles that will be required. An ingenious pupil can do something—after a time he can do much—in the way of widening his resources for making experiments, but he will at first require that the tools be ready at hand. A philosophical-instrument maker of New York, Mr. Curt W. Meyer, having been applied to for various articles suitable for rudimentary experiments in electricity, conceived the idea of meeting this demand by preparing the complete set of instruments needed for the illustration of Prof. Tyndall's book. These he has manufactured and put up in cases for transportation, so that those who wish to enter upon such a course of experiments will be spared all trouble in selecting or making the instruments necessary for the purpose. The price is such that many boys will probably be unable to procure it, but there are not many schools that by a little effort could not get the apparatus for the use of their pupils. Electricity is admirably adapted on many accounts for introducing the young to the scientific study of natural objects and agents, and in furnishing them with the facilities and equipments for the work Mr. Meyer has done them a very useful service.

Discovery of Mont Blanc.—Mont Blanc, the highest of the Alps, is, strange to say, a modern discovery. At least, no mention is made of this colossus of European peaks in any itinerary, or in any literary work whatever, till recent times. M. Charles Durier, in his work "Le Mont Blanc," says: "This mountain rises in the centre of the most populous and civilized states of Europe; it is, in fact, the axis around which European civilization has revolved and still does revolve; its height is considerable; it dominates everything in its vicinity, and, to make its appearance more striking on the background of the blue sky, its summit, though placed in a favored,

temperate latitude, is ever covered with a mantle of snow. And yet during twenty centuries no historian, no traveler, no *savant*, no poet, names it, or so much as alludes to it. As the sun describes his daily track, that peak throws its shadow upon at least three countries possessing different languages, but still it was profoundly ignored." The same author informs us of a map of the region round about Mont Blanc, published in the second half of the sixteenth century, but which gives no hint as to the existence of the mountain, which, nevertheless, is visible from all sides at distances of sixty leagues.

Earthquakes in Japan.—It is a well-known fact that the number of earthquakes in any given region liable to such disturbances is greatest in that part of the month when the moon coöperates the most effectively with the sun in producing an attraction upon the earth.

Out of forty-eight earthquakes, observed in the years 1875 and 1876, I find that thirty-seven occurred on one of the five days immediately preceding, or on one of the five days immediately following, *full moon*: in other words, that in a period of twenty-eight days there were only eleven earthquakes falling within a limit of seventeen days, while on the remaining eleven there occurred thirty-seven—a disproportion too great not to be taken into account.

I may add that, thus far, the shocks observed in 1877 are even more noticeably in accordance with the above facts.

W. E. Parson.

Tokio, Japan, *November* 3, 1877.

An Agricultural Detective Agency.—We have received the "Bulletin" for October of the Connecticut Agricultural Experiment Station at New Haven, containing analyses of thirty-one specimens of fertilizers. This "station" is prepared to test all kinds of fertilizers, seeds, cattle-foods, etc., free of charge, for the use and advantage of citizens of Connecticut. The establishment, therefore, is clearly one of great public utility, and deserving of generous support. Farmers are too often the victims of charlatans, who palm off upon them their worthless fertilizers, insect-destroyers, seeds, etc., at prices enormously in excess of their real value. This agricultural station will in time put a stop to such fraud in Connecticut. As an instance of the sort of work to be expected from the very competent chemists who make the analyses, we may cite the first table given in the present circular. Here, two kinds of fertilizing compositions are analyzed, and shown to possess about the same value as harbor-mud, but the purchaser was made to pay a very high price, indeed, for this mud, when dubbed "composition for vegetables," or "composition for grass."

A New Species of Monkey.—There are now in the Alexandra Palace, London, six live specimens of a monkey new to science, the *Macacus geluda*, a native of the mountains of Abyssinia, where it lives at an elevation of from 7,000 to 8,500 feet above the sea-level. One of these monkeys is an adult male. It is hairy over the whole of the body, with the exception of a pink patch free from hair on the chest, and a space around the throat of the same color. When the animal becomes angry or excited, these pink patches turn bright-red. The nostrils are high up from the upper jaw, and the upper lip is so mobile that it is often turned up so as to show the whole of the upper teeth and gums. The tail is long and thick, and ends in a tuft resembling somewhat a lion's tail. The color of the hair is brown, except around the breast, where it is gray. The bare part of the chest shows two male indications of teats. The female has not such long hair as the male, and on the bare spot in front are two well-developed teats. The young monkey takes one in each hand, and sucks from both at once. While these animals have rejected all fruits, they have eaten Indian-corn and grass, taking the grass, pulling it apart, and making it into little balls. In their native habitat, these monkeys sleep in caves, and in London they sleep in a large box, the old male remaining on guard near the entrance.

Invention of the Torpedo.—Perhaps the earliest of all torpedoes was that invented by David Bushnell, of Connecticut, a little over one hundred years ago. Bushnell's idea was, to fix a small powder-magazine to the bottom of a vessel, and to explode it by a

clock-work arrangement. In order to do this, he contrived a tortoise-shaped diving-boat of iron plate, which contained air enough to supply a man for half an hour. This boat was propelled by a sort of screw, and guided by means of a compass made visible by phosphorus. The torpedo was carried outside of the boat, but could be detached by the concealed operator within. It was connected by a line to a screw, which was to be driven into the bottom of the hostile ship. As soon as this was effected, the torpedo was to be cast off, when it floated against the vessel's side. The action of casting-off set the clock-work going and then the operator had time to retire to a safe distance before the catastrophe. This torpedo and submarine boat were actually tested against an English sixty-four-gun brig early in the War of Independence, but the attempt to blow up the vessel was unsuccessful. No further effort appears to have been made to turn this invention to account. Nevertheless, to Bushnell the honor belongs of having been the first to destroy a vessel by a torpedo. In an attack on the Cerberus frigate with a towed torpedo, he blew up a schooner astern of the frigate, and killed three or four men on board. This schooner was the first vessel ever so destroyed.

Human Stature.—Treating of "Human Stature," a writer in the *Revue d'Anthropologie* gives 1.585 metre (about 5.199 feet) as the lowest mean stature of males among the Esquimaux, while in some tribes of the same race the mean reaches the comparatively high figure of 1.708 metre (about 5.60225 feet). This flatly contradicts the belief that cold climates produce only men of low stature. Among the Lapps the mean stature of men is 1.535 metre, and of women 1.421 metre. The Fuegians, so far from being diminutive, are above the average stature of the human race. The Bushmen rank among the most diminutive, the average stature of both sexes being under 1.400 metre. The Akkas attain precisely the same average. The mean stature of six Obongo women, measured by Du Chaillu, was 1.428 metre. Neither the Negritos nor the Andaman-Islanders can compare for littleness with the Bushmen of South Africa. On the other hand, according to this author, the highest stature is attained by the Norwegians, in Europe, the Kaffirs in South Africa, some Indian tribes in North America, the Polynesians, and the Patagonians. The mean stature of the last-named people, according to the statements of the most trustworthy observers, is 1.781 metre (5.84169 feet); the mean of natives of the different Polynesian archipelagoes is 1.762 metre (5.77937 feet). The mean stature of the human race is about 1.600 metre (five feet three inches).

Artificial Ice.—We select from a report in the *Lancet*, on "Ice-making Machines," a description of a machine designed to produce ice on the large scale. A cistern, somewhat like a tubular boiler, contains some ether, which is the refrigerating agent. The vapor escaping from the ether is pumped, by a double-action air-pump, into a condenser surrounded by cold water; thence the ether, now once more liquid, flows back to the cistern. The evaporation of the ether causes the cistern to become intensely cold, and this cold is rapidly communicated to a strong solution of common salt, in which the cistern is immersed. The very cold brine so obtained is caused to circulate through flat, hollow, and vertical partitions of tinned copper, in a tank filled with pure water. Ice quickly forms in smooth slabs on the partitions, and is from time to time removed as the slabs acquire the requisite thickness. The ice so obtained is, of course, exceedingly pure, and is said to waste less and cost less than natural ice. In this machine the ether is condensed again and again with scarcely any loss, and the only expenses after the original outlay are, therefore, for rent, fuel, and labor.

Mineral Caoutchouc.—In presenting to the Academy of Natural Sciences of Philadelphia specimens of mineral caoutchouc from South Australia, Mr. Galloway C. Morris stated that the substance is found during the dry season in a limited area of country of a swampy nature in the Coorong district. It occurs in sheets from the thickness of writing-paper to about five-eighths of an inch. It is made into illuminating oil. Of

the basin in which it is found the surface is sand, either white and barren or brown and loamy, with occasional ridges or distributions of limestone. Next below this is segregated limestone, hard and approaching crystallization, the interstices filled with light-brown tenacious clay, followed by compact light-red sandstone of various thickness, fading in color and consistence until it touches the water and merges into quicksand. On the lowest flats fissures occur in the limestone; the orifices are very small and irregular, but reach to the underlying quicksand. The following is the result of an analysis of this mineral caoutchouc:

Moisture	0.4682
Carbon	64.7300
Hydrogen	11.6300
Ash	1.7900
Fixed carbon	1.0050
Oxygen, and other unestimated matters	20.3768
	100.0000

Living Out-of-Doors.—A retreat for consumptives should possess above all things an equable temperature throughout the year, so as to favor living out-of-doors at all seasons. The advantages possessed in this respect by the Hawaiian or Sandwich Islands can hardly be surpassed. The climate there, says Dr. H. B. White, in the "Proceedings" of the Kings County Medical Society, in its average temperature and in equability, may be said to be perfect. These islands are situated between 19° and 22° north latitude, where the trade-winds blow with great regularity about ten months of the year. Though lying within the tropics, the temperature is modified by the constant fresh breezes. In the language of Hawaii, there is no word for *weather*. The most favorable situations for consumptives are, according to Dr. White, Honolulu, Lahaina, Ulepalekua, Kailua, and Ewa. The main temperature on and near the coasts is 75° to 79° for the warmest months, and 72° for the coldest. During Dr. White's four years' residence at Lahaina the maximum was 84°, and the minimum 61°, while the general average for the summer months was 82° for mid-day, and about 72° for the winter months. By ascending the mountains a few miles inland, almost any degree of temperature can be obtained.

"Farewell."

FAREWELL! I thought you loved me once—that
dream is past forever!
Farewell! I must forget you now; that is, I
must endeavor.
From all your vows of constancy I set you free
henceforth,
And you needn't try them on again, I know now
what they're worth.

You have quite ceased to care for me; with
science you've been bitten,
Since you read that very stupid book that Mr.
Darwin's written.
I can't think what it signifies; I'm sure I never
wondered
Whether we all descended from one "type" or
from a hundred.

If you remained unaltered, I shouldn't care the
least
About the variability of any bird or beast;
But you carry out the principle of change and
variation,
So I leave you to your science—may it prove a
consolation!

I call it such a waste of time, bothering about
these things,
Racking one's brains to find out why opossums
haven't wings.
Of course, it's very curious spiders should live
on flies,
And that the tails of peacocks should be so full
of eyes.

Of course, it's all most interesting, there's not
a doubt about it,
But I think that you and I, dear, were happier
without it;
So I act on this idea of Natural Selection,
And beg you to accept of my definitive rejection.

Yet the light of all my life is quenched, my happiness gone by;
I sha'n't "struggle for existence;" I shall just
lie down and die.
Each hour I live apart from you my misery increases,
And it's all through Mr. Darwin and his "Origin of Species."

Improvements in Photography.—Both the chemist and the practical photographer will be interested in a communication from Mr. M. Carey Lea, published in the *American Journal of Science* for July on certain new means of developing the latent photographic image. It has been supposed that only very few bodies possess this singular power of developing, but Mr. Lea's researches show—1. That, on the contrary, such bodies are very numerous; 2. That, contrary to what has been generally held,

potash is a more powerful developing agent than ammonia; 3. That, so far from it being true that the most energetic form of development, when no soluble salt of silver is present, is that which depends on the use of free alkali, a most powerful development may be had *without free alkali;* 4. That ferrous salts do *not* act only in the presence of a soluble salt of silver. We have not space to describe the method followed by the author in his researches, but must content ourselves with simply stating the principal results, referring the reader who desires fuller information to the pages of our contemporary. Among the bodies found by Mr. Lea to possess the power of developing the latent image are *sugars*, manna being especially noteworthy as producing, under certain conditions, "an image as bold and strong as any substance hitherto known." Of the *glucosides* some give good images. Of several *organic acids* tried, only one, cevadic acid, exhibited tolerable developing power. The resins exhibit more or less developing power, guaiacum being nearly as energetic as pyrogallol itself. Among the *essential oils*, the oil of cloves yields a strong, clear image, and good results are also obtained from oil of Roman camomile and oil of peppermint. The *organic bases* exhibit little developing power. Concerning *pyrogallol* the author writes that with potassium formate it gives better results than with any other substance. A large number of vegetable substances were tried, with varying results. Finally, the author experimented with *cuprous oxide* and with *ferrous salts:* a colorless solution of the former in ammonia develops a strong image; but the salts of ferrous oxide "proved to be the most interesting and remarkable of all the bodies examined, in their action on the image."

Preservation of Wood by charring and tarring.—A writer in the *Industrie-Blätter*, in remarking on the methods of preserving wooden posts by charring and coating with tar, says that these methods are effectual only when both are applied. If the posts are only charred, the charcoal formed on the surface acts only as an absorber of moisture, and really hastens decay. By applying tar without previously charring, the tar only forms a casing about the wood. Timber that is exposed to the action of water or let into the ground should first be charred, and then while still warm should be treated with tar till it is fully impregnated. The acetic acid and oils contained in the tar are evaporated by the heat and only the resin left behind, which penetrates the pores of the wood and forms an air-tight and water-proof coating. It is important to impregnate the posts a little above the line of exposure, for here it is that the process of decay affects the wood first, and where the break always occurs when a post is removed from the earth or strained in testing.

Earthworms in Agriculture.—That the earthworm is of great service to the agriculturist is shown by the author of a paper, the substance of which we find in *Die Natur*. Not only does the earthworm not attack or injure the roots of plants; on the contrary, it aids them in their growth by excavating passages through which they can penetrate into strata otherwise inaccessible to them. And, as the overground portion of a plant is always proportioned to the length and number of its roots, it is plain that the earthworm is of great benefit to the plants in its neighborhood. The author placed an earthworm in a flower-pot containing a growing *Dracæna* two and a half feet in height. The worm was left undisturbed for some time, and soon it was found that it had passed through itself at least one-half of the earth in the flower-pot. The soil was in this way improved, many insoluble constituents being rendered soluble. The author's conclusion was that, inasmuch as he could discover no injury done to the roots of the *Dracæna*, the worm had fed on the remains of plants in the earth, utilizing and decomposing them thoroughly.

Drowning-Accidents.—The advantages of "paddling" and "treading water," as a means of escaping from drowning when one is suddenly precipitated into deep water, are set forth by a writer in the *Sanitary Record*. The motions performed in the acts of paddling and treading require no previous instruction, and in the great majority of cases would save life. In swimming, the mouth

is on a level with the water in the intervals of the strokes; in paddling, the head is well elevated; the individual is able to look about, he can deliberate as to what is best to be done, and he is much less liable to take water into the larynx or glottis. Without prejudice to the art of swimming, children should be exercised from the tenderest age in the act of paddling and treading water, so as to impart confidence to them. Even without any preliminary practice whatever, there is nothing to hinder man, woman, or child, from beating the water with the hands and feet, just as the lower animals do, and so keeping themselves afloat for a protracted period—a period that in a multitude of instances would be sufficient to invite rescue, and preserve life. The action of the feet alone will sustain the body; *a fortiori*, the action of both feet and hands will prove yet more effectual. In this, as in many other things, man is too often unaware of his own immense capacities.

Peppermint-Culture.—We take from the *Polytechnic Review* the following notes on the cultivation of the peppermint-plant in the United States: Of the entire crop, fully two-thirds is produced in Michigan. The soils best suited for the cultivation of peppermint are the black-ash swamps of Western New York, and river-bottoms. The land must be drained to allow it being worked early in spring. The one-year roots are planted in ploughed land in rows, the space between the rows being from eighteen to thirty-six inches. During the first year the ground must be kept free from weeds. The plant contains most oil at the period of blossoming, or just afterward, and the crop must be gathered on a dry day. Within a day or two after cutting it is carried to the still and the oil extracted. There must be a good supply of water to make distilling successful. If dried too much, there is a loss in leaves falling off, and the yield of oil greatly diminished. The mint-straw, on being dried, is readily eaten by animals in winter. The annual product is about 70,000 pounds, the greater part of it being exported to Europe.

Uses of Castor-Oil in the Arts.—Castor-oil was formerly employed only as a medicinal agent; but now its uses in the arts are manifold, and its manufacture has come to be a considerable industry. St. Louis is the centre of this industry in the United States, and nearly all the castor-beans grown in this country are produced within a circle of about 200 miles south and southwest of that city. The chief uses of castor-oil in the arts are, according to the *Shoe and Leather Reporter*, as a lubricator for coach and carriage axles, in the manufacture of the best shoe-blacking, as a dressing for calf-skins, for treeing boots, as a substitute for neat's-foot oil, and keeping leather soft, mellow, and pliable. Crude castor-oil is used largely in the manufacture of morocco. It will not "fry" or "gum," and imparts softness and weight, and leather prepared with it remains mellow and pliable. The crop of castor-beans for the year 1875 was 303,498 bushels; in 1876 the crop was only about one-half as large. Last year a firm in St. Louis made, from 125,000 bushels of beans, 7,000 barrels (47 gallons each) of crude castor-oil.

NOTES.

THERE will be two solar eclipses this year, one on the 1st of February, the other on the 29th of July. The former will be central and annular as observed from high southern latitudes; the latter will be total in the western part of North America. It will be best observed at Denver, Colorado.

THE "Copley Medal" for 1877 has been awarded by the London Royal Society to Prof. James Dwight Dana, of Yale College, for his biological, geological, and mineralogical investigations carried on through half a century, and for the valuable works in which his conclusions and discoveries have been published.

A PRIZE of $20,000 is offered by the Council General of Guadeloupe for the best new process for extracting the juice from sugar-cane, the cost not to exceed 40 per cent. of the market value of the product. The prize is open to competition till June 1, 1880.

NUMEROUS facts are cited by the Australian explorer, Landsborough, which go to prove that dense forests are on the increase in Australia, that the climate is growing moister, and that even the great central desert may, in course of time, become inhabitable. The frequency of fires, prior to the introduction of sheep-farming, when there was nothing to keep down the grass, was

terribly destructive to trees and to all vegetation. Now these ravages are becoming limited in extent.

KARL LUDWIG VON LITTROW, Professor of Astronomy, and Director of the Imperial Observatory at Vienna, died at Venice, November 16th, in the sixty-seventh year of his age.

THE mean distance of the sun, as deduced by the British Astronomer Royal, Sir George Airy, from a comparison of the results obtained by the English telescopic observations of the transit of Venus in 1874, is equal to 93,300,000 miles. But, as the photographs of the transit are yet to be worked up, this estimate must be regarded as provisional only.

DR. H. C. YARROW, of the Army Medical Museum, Washington, is collecting materials for a memoir on the burial-customs of the North American Indians, both ancient and modern, and earnestly solicits information so as to enable him to treat the subject with all possible fullness. Correspondents are requested to state as exactly as may be the name of the tribe concerning which they give information, its locality, its manner of burial, ancient and modern, its funereal and other mortuary ceremonies, etc. Dr. Yarrow's address is 1,747 F Street, N. W., Washington.

DOUGLAS A. SPALDING, author of many suggestive papers on certain obscure questions in psychology which have appeared in the MONTHLY, died on the 31st of October, in the thirty-seventh year of his age. From a notice in *Nature* we learn that Mr. Spalding was in his early manhood a slater at Aberdeen; in 1862, through the kindness of Prof. Bain, he was allowed to attend free of charge the classes in literature and philosophy in the university. Later he went to London, and tried to earn a livelihood by teaching, at the same time studying law. His paper on the instinctive movements of young birds, read at the British-American meeting of 1872, first brought him to the notice of the world of science.

AT a *conversazione* lately held in Guy's Hospital, London, a filter invented by a Major Crease was exhibited. It reduced strong tea and logwood infusion to clear, tasteless water. The nature of the filtering medium is at present a secret.

A PRIZE of $25,000 is offered by the government of India for the best machine or process for preparing *rhea* or ramie-fibre; also a prize of $5,000 for the second best. The conditions of winning the prize are that the machine or process shall be capable of producing by animal, water, or steam power, one ton of dressed fibre at a total cost not exceeding $75 at any port in India, or $150 in England. The machines must be in readiness at Saharanpar by August 15, 1879.

A SOLUTION of bicarbonate of sodium applied to burns promptly and permanently relieves all pain. A laboratory assistant in Philadelphia having severely burned the inside of the last phalanx of the thumb while bending glass tubing, applied the solution of bicarbonate of soda, and not only was the pain allayed but the thumb could be at once freely used without inconvenience.

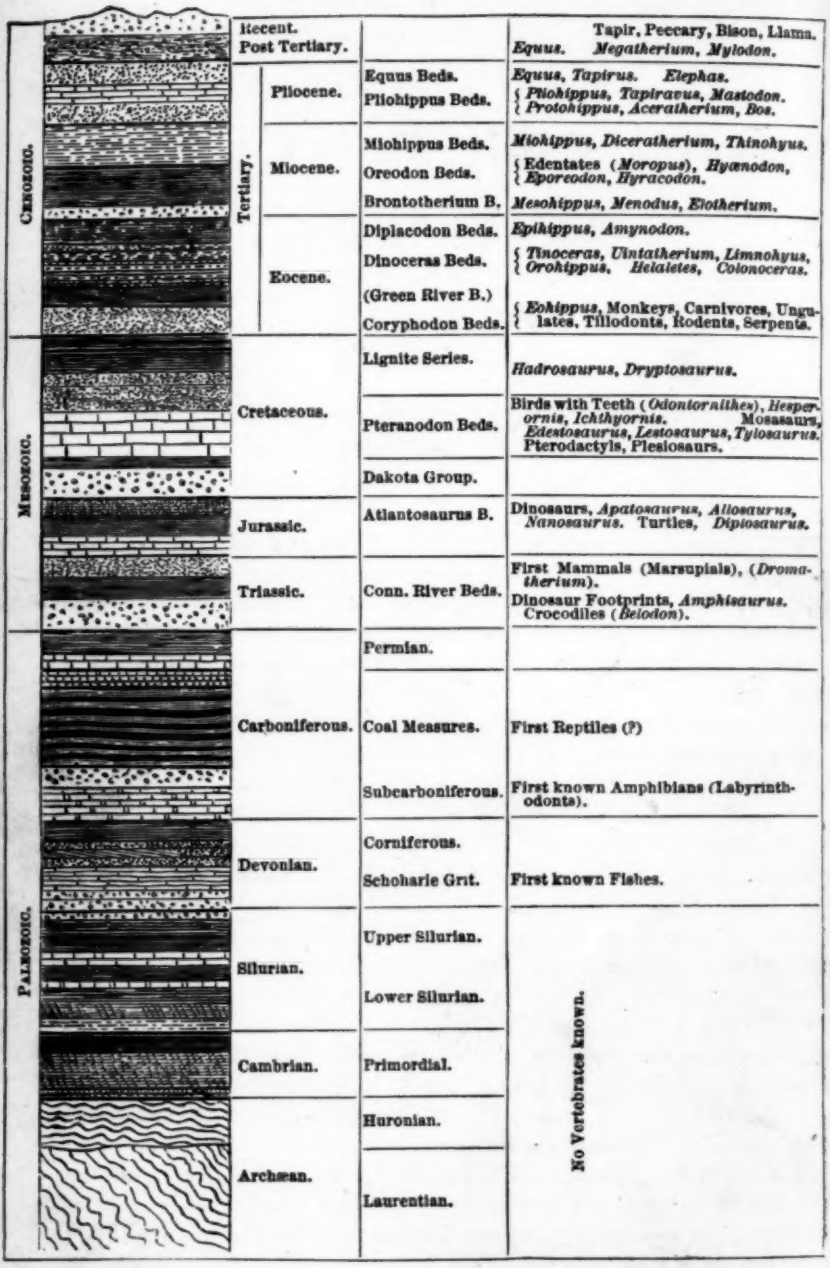
MUNKE quotes from the "Talmud" a passage in which mention is made of iron as a means of "protection from lightning and thunder;" and Wiedermann adds that the ancient Egyptians appear to have used gilded masts "for warding off the bad weather coming from heaven."

ON board the British iron-clad ship Téméraire, besides the great engines for propulsion, there are no less than thirty-four small engines for the following purposes: two turning, two starting, four feed, two circulating, two fan, two bilge, one capstan, one steering, four pumping, four ash-lifters, two hydraulic gear-workers, one torpedo reservoir-charger, one to work the electric machine which lights the bridge, and four others.

NEARLY all the salt used for domestic purposes passes out with the sewage, and is inseparable from it; the proportion of salt (chloride of sodium) found in water is therefore a pretty accurate measure of the degree of contamination by sewage. Hence, says Prof. Lattimore, of Rochester, "whenever the proportion of salt in well-water rises above a very few grains per gallon, contamination by sewage or house-drainage may be confidently asserted."

A SINGULARLY interesting discovery has been made by Reichenbach, with regard to the embryo of the crawfish. He finds that the "food-yelk" of the egg is not merely absorbed by the embryonic cells by a passive process of diffusion, but that these latter actually devour the yelk-globules in precisely the same manner as an amœba devours diatoms or desmids. The cells throw out pseudopod-like processes, and with these envelop the yelk-globules and drag them into their interior, where they undergo digestion.

THE sermon of Henry Ward Beecher on the subject of future rewards and punishments, concerning which there has been such gross misrepresentation, is published in full in the *Christian Union* (New York) of December 26th. It is entitled "The Background of Mystery."



Section of the Earth's Crust.

TO ILLUSTRATE VERTEBRATE LIFE IN AMERICA.